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No. 6.—Dr. Baxter's Report on an Experimental Study of certain Disinfectants.

I. Introductory.

App. No. 6.

On Disinfectants, by Dr. Baxter.

Various meanings assigned to the term "disinfectant."

The term "disinfectant" has been, and still is, employed to designate agents possessing one or more of the following properties:

1°. That of checking or preventing certain chemical changes due to the operation of azotised ferments, and seemingly independent of the presence of living organisms. The word "catalysis" is used to specify, without in any way elucidating, the nature of such changes. Examples of them are furnished by the action of emulsin upon amygdalin, of diastase on starch, &c.

2°. That of preventing or stopping decompositions which are causally connected with the presence of organisms. Looked at from the biological rather than the chemical point of view, such changes naturally fall under at least two heads, viz., *fermentations*, occurring in acid media, and attended by the germination and multiplication of toruliforms; and *putrefactions*, occurring in neutral or alkaline media, and associated with the presence and vital activity of schizomycetous organisms.

3°. That of destroying the injurious products of any of the above processes, or of rendering them innocuous to man and the higher animals.

4°. That of destroying the contagia of communicable * diseases, or of depriving such contagia of their specific infective power.

Advantage of a precise definition of the term.

It is desirable, for several reasons, that the denotation of the term "disinfectant" should be more rigidly circumscribed, and thereby rendered more precise. The necessity for some such limitation is recognized by a majority of the highest authorities on the subject. Dr. Parkes, for instance (*Practical Hygiene*, 4th edition, 1873), after enumerating the various senses in which the word is used, goes on to say, "By a third party it is used only to designate the substances which "can prevent infectious diseases from spreading by destroying their "specific poisons. This last sense is, I conceive, the most correct, "and it is that which is solely used here." So, too, in the "Memorandum on Disinfection" issued by the Medical Officer to the Privy Council (1866), "those true disinfectants which permanently destroy infective matters" are distinguished, in a preliminary note, from "those agents which merely arrest the progress, or absorb the offensive products of organic decomposition." By narrowing the scope of the inquiry and placing its objects in a clearer light, a precise definition will pave the way for their more speedy realisation. Again, it fixes attention on the right method to be pursued, the only method by which results of incontestable value as regards practice can ultimately be reached. It enables us to avoid the tacit assumption which underlies the indiscriminate application of the term "disinfectant" to substances endowed with the properties mentioned under 1, 2, and 4; for even those authors who eliminate group 3 under the name of "deodorants,"* retain to a greater or less extent the confusion of the remaining three. The tacit assumption is that catalysis, fermentation, putrefaction, and contagion, are fundamentally similar or closely related processes; a view which may be more or less near the truth, but which cannot be regarded as established on a rigidly experimental basis.

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* This word is meant to cover the whole ground which is at present unequally and vaguely distributed between the two epithets "contagious" and "infectious." Every attempt to establish a definite boundary line between their respective provinces rests upon a fundamental misconception of the difference which seems to exist between the mode of propagation of a disease like syphilis, and of one like typhus. There is every reason to believe, as will be shewn further on, that the difference is one of degree only, not of kind; hence it appears better to use a word, like that in the text, with which no distinctive theory of propagation has been connected.

The definition of a disinfectant which will be adopted in the following pages is this: any agent capable of so modifying the contagium of a communicable disease, during its transit from a sick to a healthy individual, as to deprive it of its specific power of infecting the latter. This definition at once restricts the problem within clear limits, and does away with much of the vagueness which has hitherto been allowed to cling to it. A disinfectant is only designed to act upon contagious matter after it has been given off by the generating organism, and before it penetrates into a healthy one. The field of usefulness open to it will evidently be wider in the case of diseases communicable at a distance, such as small-pox or scarlet fever, than in the case of those which are usually communicated by immediate contact, such as syphilis.

Methods of determining disinfectant power.

We may reasonably pause to inquire how it is that the meaning of disinfection is so differently understood by different inquirers, and that the term "disinfectant" is so loosely employed by the majority of them. Two causes appear to have contributed very materially to this result: the rudimentary state of our knowledge concerning the intimate nature of contagion, and the difficulty of obtaining any direct test of the real disinfectant power of any given agent. As regards the first point, it is evident that until pathologists have come to an agreement on several fundamental questions, the use of disinfectants must remain to a great extent empirical. So long, for example, as it is doubtful whether the contagium of enteric fever be invariably derived from a previous case, or generated *de novo* in any accumulation of putrefying sewage, the problem of disinfection in that disease must continue vague. So, again, the difficulty of getting at any *direct* test of the efficacy of a disinfectant, in the strict sense of the word, is well illustrated by the following quotation from Dr. Parkes, which marks out the extent of our knowledge, or rather of our ignorance, in this department; he is speaking of the effect produced on the contagia by chemical agents, or heat, or cold, in different diseases: "Our knowledge of this point is " very imperfect, as it is necessarily derived simply from seeing if the " spread of any contagious disease seems arrested by the disinfecting " measures we employ. The experiment is a coarse one, and is con- " ducted under all possible difficulties." It is partly owing to the absence of any direct test that inquirers have been driven to rely upon indirect methods; such methods depending in each particular case on the pathological preconceptions of the individual. He who believes contagion to be propagated by albuminoid principles in a state of molecular change, will naturally lean towards such agents as are capable of precipitating or oxidising albuminous compounds, and will employ these properties as a test of disinfectant efficacy; he who adheres to one form or other of the germ theory, will classify disinfectants according to their action on protoplasm, on fermentations, or on putrefactions.

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* That even this distinction between disinfectants and deodorants is by no means universally observed, may be seen in the following quotation from the article on disinfection in the *Dictionnaire de Médecine Pratique* (1869): "D'une manière " générale on appelle *désinfectant* toute substance propre à détruire l'odeur infecte " qui accompagne la décomposition naturelle des matières organiques, et à assainir " certains lieux ou des matières putrides."

On Disinfectants, by Dr. Baxter.

Their relation to our views concerning the intimate nature of contagion.

Now although it be true that before disinfection can be made to rest on a thoroughly scientific basis, our knowledge respecting the pathology of contagion must be very much more complete than it is, it may yet be possible to arrive at conclusions of practical value by experimenting with matters which are known to have the power of communicating specific diseases, setting aside for the nonce the question with which of their constituents their infective capacity may be bound up. If a reputed disinfectant be allowed to act on any such material, and the latter be subsequently inoculated, the positive or negative result of inoculation must needs furnish a reliable test of the ability of the disinfectant to fulfil the duty laid upon it. And the practical value of this experimental test will be wholly independent of any theory as to the precise nature of the *materies morbi.* Indirectly, of course, the results obtained may seem to harmonise more nearly with one or other of the views respecting contagion which now divide the field of pathology among them; but such support as they may bring to any of these theories will be accessory and not essential to the primary object held in view. Indeed, the method of inquiry now advocated differs from almost all those which have been hitherto adopted in this very quality of independence of all pathological preconceptions.

It is important to bear continually in mind the characteristic feature by which the contagium or virus of a communicable disease is distinguished from every other kind of hurtful or poisonous matter. The characteristic quality of a virus is not its animal origin, for of its ultimate origin we know nothing; not that it gives rise to a constant and invariable train of symptoms associated with definite structural alterations, for many poisons do the same; but that it is capable of undergoing almost unlimited multiplication when introduced into an appropriate medium, that medium being the body, or part of the body, of a certain animal or animals; consequently, its effects are to a great extent independent of the quantity introduced, dilution lessening the chances of infection, but not modifying its specific characters when it *does* occur. It follows that nothing short of the complete destruction of *all* the virulent matter from which danger is apprehended can guarantee us against the indefinite propagation of the disease which is being combated by disinfection. And further, that the only legitimate test of the effectual disinfection of any virulent substance is its inability, when introduced into a suitable host or medium, to bring about the specific train of phenomena which coincide with its own multiplication.

Difference between contagion and infection only one of degree.

One other point should be premised, which, though not essential to the fertility of the above method in results of practical usefulness, is needed for the due interpretation of those results. This point is the particulate nature of contagia, which has been demonstrated in the case of small-pox, cow-pox, glanders, and ovine variola,* and which may be provisionally extended, as a legitimate hypothesis, to other contagia. The fact that the infective principle of these disorders is neither soluble nor diffusible, carries with it the corollary that neither can it be volatile. This last conclusion is supported by bedside experience; it has been pointed out that were the contagium, *e.g.*, of small-pox volatile, the air surrounding a patient labouring under that disease would constitute an uniformly infected medium into which no unprotected person could penetrate, even for a few moments, without extreme risk. That no such excessive degree of risk is run, confers an *a priori* probability on the view that the contagious principle exists in the air in the same form in which it exists in liquids, viz., in the form of solid particles, and is therefore unequally distributed. But to this *a priori* probability may be added the evidence of direct experiment. Three diseases which enjoy in the highest degree the fame of being communicable at a distance are small-pox, variola ovina, and cattle-plague. If it be experimentally proved that the contagia of these three diseases are not volatile, the generalisation may fairly be extended, until further notice, to other infectious maladies. This experimental proof has been supplied by M. Chauveau (*Comptes Rendus*, 1871, p. 116). He introduced virulent liquids derived from individuals labouring under each of the three diseases in question into small glass cups, embedded in a sand-bath which was kept at a temperature of 40° C. A small bell-glass was inverted over each cup, and maintained at a low temperature by having its outer surface moistened from time to time with ether. The water in the liquids underwent evaporation, and was condensed on the walls of the bell-glass. Now, supposing the virulent principles to have been volatile, they would naturally have risen with the watery vapour and mingled with the condensed droplets, conferring upon these a specific infective power. But, as it turned out, the condensed water, when collected with a capillary pipette, and suitably inoculated, proved to be entirely free from virulence in every one of the instances referred to.

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* See *Twelfth Report of Medical Officer of the Privy Council.*

Importance, as regards disinfection, of media in which contagium is suspended.

Granting that the contagious principle is neither soluble, nor diffusible, nor volatile, and that it invariably consists of particles of extreme minuteness, it follows that all distinction between contagion and infection must cease. The one is communication by direct contact, the other, communication at a distance; but the mode of communication is the same in both cases, viz., the transfer of certain solid particles from the infected to the healthy organism. But this recognition of the unity of the contagious principle must not blind us to the fact, all-important in reference to disinfection, that it may be transferred from the sick to the healthy either by means of a solid, a liquid, or a gas. These three states of matter stand in no closer relation to the contagium than that of media or vehicles; media, in which it may sojourn for an indefinite time without forfeiting its infective property; vehicles, by which it may be carried from the sick to the healthy. This point may be illustrated by the example of small-pox, whose virus may be conveyed in a liquid form, derived from a characteristic vesicle; or as a solid crust from a dried pustule, or a patch of dried mucus on a handkerchief; or, finally, it may be air-borne, or perhaps, more correctly, dust-borne. The virus, in all three forms, retains its characteristic activity; it consists of the same particles; but it is obvious that, as regards disinfection, its susceptibility is not the same. A liquid non-volatile disinfectant might act powerfully on the first, feebly on the second, and not at all on the third. This consideration of the medium in which the virulent particles are suspended seems, as we shall see hereafter, to afford a clue whereby some perplexities may be unravelled and some apparent discrepancies reconciled.

Present inquiry limited to four disinfectants most commonly employed.

The object of inquiry and the method to be pursued having been thus defined, a further limitation is introduced, on the present occasion, by the choice of four only out of the multitude of disinfectants indiscriminately used by practical men. These four are *potassic permanganate*, *sulphur dioxide*, *chlorine*, and *carbolic acid*. The very general preference shewn for these four agents may be ascribed rather to motives of expediency than to any theoretical conviction of their absolute disinfectant power. Reasons of expense bar the employment of such substances as iodine and bromine; the stronger mineral acids are too generally destructive to be entrusted to any but experts, and are, even then, of limited applicability. Again, the four agents in question have been known for years, and rudely tested on a large scale; they have been investigated in various ways, and dogmatic assertions have been made concerning their relative usefulness; and yet it is singular, when the matter is looked into, how scanty is our knowledge about their real disinfectant power, as tested by the only method capable of yielding absolute results.

In the experiments hereafter to be described, Calvert's purest crystalline carbolic acid was used, dissolved in distilled water. The solutions of potassic permanganate were prepared by weighing the crystalline salt, and dissolving it in distilled water at the moment of use. Chlorine was generated in the usual manner from hydrochloric acid and manganese dioxide; the solution was preserved in a black bottle, duly stoppered, and kept cold. The sulphur dioxide was obtained by the action of concentrated sulphuric acid on copper turnings. The solutions of chlorine and sulphur dioxide were invariably titrated after each experiment; the former with potassic iodide and decinormal solution of sodic hyposulphite, the latter with decinormal solution of iodine. They were always used as fresh as possible, and seldom kept for more than a week.

Contagia chosen for treatment by these agents.

The contagia selected for disinfection were vaccine, the virus of infective inflammation in guinea-pigs, and the virus of glanders. A series of experiments with the virus of ovine variola was projected, but not carried out, owing to a difficulty in obtaining a supply of material for starting the inoculations. It need hardly be said that the choice of these three infective substances was chiefly determined by reasons of expediency. Any results obtained from experiments with vaccine lymph owe their practical value to the pathological affinity between cow-pox and small-pox. Further, vaccine is the only specific virus with which experiments can legitimately be conducted on the human subject. Again, it is one of the few communicable diseases concerning whose intimate pathology we possess definite experimental data of high value. This last advantage is shared by glanders, a disease eminently communicable both by contagion and infection, producing specific dynamical and structural effects, and having the additional recommendation, that while it admits of being studied by inoculation on certain of the lower animals, it is also susceptible of being communicated to man in its most virulent form.

The virus of infective inflammation in guinea-pigs stands in a somewhat different position. For we are able to generate it *de novo;* and so far it cannot be regarded as specific, in the proper sense of the term. But it is endowed with what has previously been noticed as the distinctive mark of a virus, viz., the faculty of undergoing indefinite multiplication in the infected organism. Moreover, it produces pathological results which are tolerably definite and constant, depending only to a limited extent, if at all, on the amount of material introduced. So that, for our purposes, it may be said to resemble the specific contagia more than it differs from them.; and it has this practical advantage in its favour, that it can be procured in considerable quantity, allowing experiments to be repeated and varied to a greater extent than those with vaccine or the virus of glanders.

Theoretical purpose of the present investigation.

It may be well to state that the main object of such an inquiry as the present one is to furnish materials for the theoretic basis on which all practical rules for disinfection must rest. We do not certainly know that *any* of the agents habitually employed possess real disinfectant power; we have no experimental data as regards their comparative efficiency and the various circumstances which must modify their operation in particular instances. The present Report can do no more than furnish a nucleus of positive observations, limited in intention and still more in execution, round which facts of the same order may hereafter be accumulated; and fix attention on what is believed to be the right road along which future inquiries of this kind ought to travel.

The ensuing sections will be devoted to the action of the disinfectants already enumerated upon vaccine virus, upon the virus of infective inflammation, upon that of glanders, and finally upon the germinal matter of septic microzymes; the last-named section being an endeavour to ascertain whether an underlying harmony may not be found to exist between the disinfectant operation of the substances specified above, and those other properties which have hitherto been very generally confounded with, or taken as evidence of, their truly disinfectant power.

II. Experiments with the Virus of Vaccine.

Relation of vaccine virus to those of human small-pox and variola ovina.

The principal reasons which led to the choice of vaccine virus, as a test of the efficiency of disinfectant agents, have already been alluded to. The affinity of vaccinia to small-pox gives a high degree of practical value to any experimental results which may be obtained in connexion with it; moreover, it has been more closely studied, as regards its intimate nature, the conditions of its activity, and the specific results to which it gives rise, than any other kind of infective matter.

Difference between their respective transmissibility accounted for: Chauveau's experiments.

The virus of cow-pox is not known to be communicable otherwise than by direct contact or inoculation. There is no instance on record of the disease having been transmitted by aerial infection. In this respect, therefore, it differs *primâ facie* from its congeners, the contagia of small-pox and variola ovina, both of which are believed to be readily communicable through the air. Considering the very close analogies which subsist between these three diseases, there is reason to think that this contrast may be due, not so much to any intrinsic difference between the contagious particles by which they are respectively propagated, as to differences in the amount of virulent matter generated in the infected organism, and in the facilities afforded for the distribution of this matter through the surrounding medium. This view has been very lucidly developed by M. Chauveau. Inasmuch as not one of the three contagia is volatile, infection at a distance can only take place by the transfer of particles derived from the diseased individual to some absorbent surface in the healthy one. Such absorbent surfaces are to be found in the mucous membranes lining the air-passages and the alimentary canal. That the virulent matter is capable of being absorbed from the intestinal surface, and causing all the phenomena of constitutional infection, has been experimentally proved in the case of ovine variola; and this result may reasonably be extended to the two allied disorders. Now when we consider the number of distinct foci, each yielding a large amount of infective matter, distributed over the skin of a sheep suffering from the severer form of ovine variola, or of a man affected with small-pox; when we recollect, further, that similar infective foci exist elsewhere in the body (notably in the lungs of the sheep, where secondary nodules full of virulent particles are often developed) in situations which enable their products to be discharged into the surrounding medium by coughing; we cannot but be struck with the contrast between these two diseases and cow-pox as it occurs after inoculation in the human subject. The quantity of infective material generated in the latter, though very considerable in relation to the amount introduced, falls very far short of the enormous supply yielded by a single case of ovine or human variola; and what there is, is generated in a situation which absolutely precludes its distribution throughout the environment, at least during the period when the infective power of the contagium is at its highest.

Since the difference between the communicability of vaccinia on the one hand, and small-pox on the other, admits of being thus easily explained, it appears superfluous to go farther afield in search of causes; those enumerated are *veræ causæ*, and they are competent to explain the facts. Accordingly we may assume that the difference is one of degree only, and that deductions from experiments performed with the contagium of cow-pox may be extended to variola.

Nature of media in which the particles of vaccine are contained.

The virus of vaccinia may be preserved either in a liquid or a solid medium. In the former, when lymph exuding from a pricked vesicle is collected in capillary tubes; in the latter, when ivory points are coated with the dry residue of its evaporation. The present series of experiments will accordingly be divided into two groups, one devoted to the action of the disinfectant agents, enumerated above, upon fluid lymph; the other to their action upon dried lymph. The results of the latter group will obviously serve as materials for the estimation of the comparative efficacy of gaseous disinfectants; indeed, it is very probable that "aerial disinfection," when distinguished, as it should be, from the destruction of noxious gases in the atmosphere, is really exerted upon contagious particles embedded in dry mucus or albuminoid matter of one kind or another.

Method of testing the action of disinfectants on liquid vaccine.

The inquiry into the action of disinfectants on the virulent particles suspended in liquid vaccine was conducted in the following manner. Four capillary tubes having been charged from one vaccinifer, the contents of two of these were diluted with an equal volume of half per cent. saline solution (·5 grm. of NaCl in 100 c.c. of distilled water); the lymph contained in the other two was mixed with an equal volume of disinfectant solution of known strength. The diluted and the disinfected liquids were sealed up in separate tubes, and employed for vaccinating a healthy infant; the former being inoculated in three places on the left arm, while the latter was introduced into an equal number of places on the right arm, two lancets being employed for the purpose. The inoculation was performed by scratching, not by puncture. The results were observed and recorded on the eighth day. By adopting this method, several sources of possible error were from the first eliminated. The uniform potency of the lymph within the compass of each single experiment was ensured by its being derived from one vaccinifer. The degree of dilution was the same in the disinfected as in the virgin virus. Finally, the inoculation being performed on opposite arms of the same individual, no difference of idiosyncrasy could vitiate the comparative result.

The difficulty of dealing with such very small quantities of material as are furnished by the vesicles on an infant's arm had to be overcome by a special contrivance. Only four of Husband's tubes, little more than half full, could be obtained for each experiment. It was necessary to devise some means whereby the contents of these tubes could be accurately measured, and mixed with an exactly equal volume whether of saline or of disinfectant solution.

To attain this end the following apparatus was constructed. Two thermometer tubes of small bore, about 28 centimètres in length, were calibrated with a globule of mercury, and divided into 15 equal parts, each of which measured nearly 1·5 centimètres. Each of these divisions was further subdivided into five equal parts. About four centimètres of the upper end of each tube, and 1·5 centimètres of its lower end, remained without graduation.

The lower extremity of each tube was ground down to a point just large enough to include the orifice of the axial canal. Thus each fractional part of either tube was made precisely equivalent to all the rest. These graduated tubes will hereafter be known as pipettes.

The two pipettes were supported on a stand consisting of a vertical pillar screwed into a heavy plate of metal, upon which a cross bar 30 centimètres long moved up and down, and could be fixed at any height by means of a screw. The two arms of the horizontal bar projected to an equal distance on either side of the pillar. To the extremities of the bar two perforated corks were attached by pieces of very thick, yet flexible, wire: the pipettes were introduced into these perforated corks, by which they were tightly gripped. The capillary end of each pipette was directed downwards, inwards, and forwards. Their distance from the table could be varied by sliding the horizontal bar on the vertical pillar, while the direction of their axes could be altered at will, and retained at any desired angle, owing to the flexibility of the wires connecting the corks with the ends of the horizontal bar. Over the upper end of each pipette, when fixed in position, was slipped a piece of gutta-percha tubing, the other end of which fitted a glass mouthpiece; the two mouthpieces being fixed side by side within easy reach of the operator's lips.

The following are the steps of the process. One pipette is charged with saline solution by suction; the liquid is retained by capillarity. Two of the vaccine tubes are then emptied on to a clean slide, and the minute coagulum, which is often present, is drawn aside with a glass thread. The drop is then cautiously brought under the nozzle of the other pipette and the lymph sucked up. The number of measures which it occupies are read off, and it is forthwith expelled very gently on to another slide. An equal number of divisions of saline solution are added from the companion pipette, and the two droplets are thoroughly mingled by stirring with a thread of glass. The mixture is then introduced into a capillary tube and sealed up. Both pipettes are washed out with saline solution, and the two remaining tubes of lymph are mixed in exactly the same way with an equal volume of the disinfectant solution.

These manœuvres, after a little practice, cease to present any difficulty, though they demand time and trouble. It is very important to expel the lymph from the pipette *immediately* after its volume has been read off; otherwise there is great risk of its coagulating in the tube. Again, the attenuated canal of the pipette, where it terminates in the nozzle, is very liable to become blocked; hence, should the droplet of lymph contain visible particles or coagula, it must be manœuvred in such a way as to keep these out of reach of the suction-current. When the operation is carefully executed, no bubbles appear in either pipette; they should be strenuously avoided, as they impair the accuracy of the measurements.

Experimental inoculations with liquid vaccine.

Three sets of experiments were performed with liquid vaccine, the agents employed being potassic permanganate, chlorine, and carbolic acid. The experiments with sulphur dioxide proved a failure, owing to some chemical change which caused the mixture of lymph and acid to gelatinize firmly in the capillary tubes.

Action of Potassic Permanganate on Liquid Vaccine.

No.	Proportion of Permanganate in the Material inoculated.	Number of Vesicles on Arm inoculated with diluted Vaccine.	Number of Vesicles on Arm inoculated with disinfected Vaccine.	Remarks.
1	·025 per cent.	2	0	
2	·025 ,,	2	2	Vesicles of the same size on both arms.
3	·05 ,,	3	3	
4	·1 ,,	3	3	
5	·5 ,,	3	0	
6	·5 ,,	1	0	
7	·5 ,,	2	0	

These experiments point to a result which stands midway between the exaggerated value ascribed to the permanganate by some authors, and the total repudiation of its claims by others. (O'Nial, for instance, concludes that the permanganate is a useful deodorant, but has scarcely any germicide power.)

It is evident that the proportion of permanganate required to destroy the infective energy of vaccine is relatively large; but that, in such excess, it is capable of doing the work.

Action of Chlorine upon Liquid Vaccine.

No	Proportion of free Cl. introduced into the Material inoculated.	Number of Vesicles on Arm inoculated with diluted Vaccine.	Number of Vesicles on Arm inoculated with disinfected Vaccine.	Remarks.
1	·00185 per cent.	3	3	Lymph is alkaline; contains no free Cl.
2	·00369 ,,	2	3	
3	·0204 ,,	2	2	
4	·0408 ,,	3	2	
5	·07105 ,,	3	1	
6	·09413 ,,	3	3	
7	·09413 ,,	3	1	
8	·1421 ,,	2	2	
9	·1633 ,,	3	0	Lymph distinctly acid.

The negative results furnished by the first eight inoculations were unexpected. The lymph, after admixture with the solution of chlorine, was found, in every case, to have retained its alkaline reaction and to contain no trace of free Cl. In the ninth experiment, however, in which the vaccine was satisfactorily deprived of its infective energy, it was found to be distinctly acid after the chlorine water had been added to it. It would appear then that chlorine, unless it be added in sufficient quantity to render the lymph acid, has no appreciable influence in restraining or abolishing its infective power.

ACTION of CARBOLIC ACID upon LIQUID VACCINE.

No.	Proportion of Carbolic Acid in Material inoculated.	Number of Vesicles on Arm inoculated with diluted Vaccine.	Number of Vesicles on Arm inoculated with disinfected Vaccine.	Remarks.
1	·25 per cent.	3	3	
2	·5 "	3	3	
3	·5 "	3	3	
4	1 "	2	0	Vesicles very small.
5	1 "	3	1	
6	1 "	3	3	
7	1·5 "	2	0	Vesicles large on arm inoculated with diluted lymph; very small on arm inoc. with carbolized lymph.
8	1·5 "	3	0	
9	1·5 "	3	3	
10	1·5 "	3	2	
11	2 "	3	0	
12	2 "	2	0	
13	2 "	3	0	

It is sufficiently evident from these experiments that the presence of 1 per cent. or less of carbolic acid in vaccine exerts no influence upon its activity. When the proportion of acid present is between 1 and 2 per cent., the effects of inoculation are irregular. 2 per cent. seems enough to destroy its infective power with certainty.

Method of testing action of disinfectants on dried vaccine.

The next series of experiments was designed to test the efficacy of gaseous disinfectants upon dried vaccine. The following was the simple method pursued. Six points were charged from one vaccinifer and dried. Some days later, three of the points were exposed to the action of chlorine, sulphur dioxide, or the vapour of carbolic acid. To be able to compare the relative power of these three agents, it is necessary to vary either the degree of concentration of the gaseous medium to which the dried virus is exposed, or the duration of its exposure. The latter variable is obviously more under our control than the former one. In the case of carbolic acid, it is well-nigh impossible to obtain an atmosphere containing a given per-centage of the vapour diffused through it; and the chemical activity of chlorine interferes with its treatment by any such method. Accordingly the time of exposure was alone varied, the virus being always exposed to an atmosphere saturated with the gas or vapour at the ordinary temperature of 60°–65° F.

A wide-mouthed four-ounce glass bottle, with a hollow ground stopper, was used as the chamber in each case. The cavity in the stopper was filled with cork, in which three slits were cut, each sufficiently large to admit and retain the broad end of an ivory vaccine-point. The bottle was filled to one-third of its depth with a saturated solution of chlorine or sulphur dioxide, or with nearly pure carbolic acid. Three points were fixed into the stopper, which was then replaced. The charged ends of the points were thus kept within half an inch of the surface of the liquid, and exposed to the full influence of any gas or vapour rising from it. After exposure for a given time they were removed and preserved apart from their fellows. Two or three days later, the three disinfected points were used to inoculate three places on one arm of an infant, while the corresponding places on the other arm were vaccinated with the virgin points.

Effect of simple desiccation on vaccine lymph.

One trial was made to ascertain whether desiccation over concentrated sulphuric acid would modify the infective power of the dry virus. Three points were kept under a small bell-jar into which a basin of concentrated oil of vitriol had been introduced, for 52 hours; the edges of the bell-glass were ground and cemented to a glass plate. On inoculation, the dried points yielded three plump vesicles, exactly similar to those produced on the opposite arm by the three corresponding points which had not undergone any sort of treatment.

Experimental inoculations with dried vaccine.

The three following tables exhibit the results of the experiments made with chlorine, sulphur dioxide, and carbolic acid vapour respectively:—

Action of Chlorine on Dry Vaccine.

No.	Duration of Exposure.	Number of Vesicles on Arm inoculated with Virgin Points.	Number of Vesicles on Arm inoculated with disinfected Points.	Remarks.
1	5 minutes	3	1	The vesicles produced by the virgin points were all large; those furnished by the disinfected points, very small.
2	10 „	3	1	
3	15 „	3	2	
4	30 „	2	0	
5	30 „	3	0	

Action of Sulphur Dioxide on Dry Vaccine.

No.	Duration of Exposure.	Number of Vesicles on Arm inoculated with Virgin Points.	Number of Vesicles on Arm inoculated with disinfected Points.	Remarks.
1	10 minutes	3	0	
2	do.	3	0	
3	do.	2	0	
4	do.	3	0	

Action of Vapour of Carbolic Acid on Dry Vaccine.

No.	Duration of Exposure.	Number of Vesicles on Arm inoculated with Virgin Points.	Number of Vesicles on Arm inoculated with disinfected Points.	Remarks.]
1	5 minutes	3	1	No constant difference observed between vesicles furnished by carbolized and those furnished by virgin points.
2	10 „	3	3	
3	15 „	3	1	
4	20 „	3	3	
5	30 „	3	2	
6	30 „	2	0	
7	60 „	3	0	
8	60 „	3	0	

One striking result is manifest from this series of inoculations. It is the very marked superiority of sulphur dioxide to carbolic vapour and chlorine gas, and this under conditions which seem, above all others, to render the virulent particles least susceptible to destructive influences. It is sufficiently obvious that the quantity of chlorine given off into a room from a basin filled with chloride of lime, or the vapour of carbolic acid generated in a vaporiser, would be utterly inadequate to destroy vaccine virus, and, by inference, the contagium of small-pox, when embedded in a matrix of dried albuminous matter; and it is not unlikely that the virulent matters for whose destruction aerial disinfection is employed are commonly protected in some such way.

The only experiments relating to the disinfection of vaccine virus of which I have been able to find any record, are those of Dr. Henry (1831), Mecklenburgh, and Dougall. None of these observers appear to have investigated the action of destructive agents upon the dried virus, and some of their results are open to question; but the exceeding dearth of facts will not allow of any experimental data being neglected.

Results obtained by Mecklenburgh.

Mecklenburgh,* in a preliminary notice, makes the following assertions, without, however, giving any details as to the number of experiments performed or the methods employed: 1°. That the exposure of vaccine lymph, diluted with its own volume of glycerine, to the action of chlorine (under a bell-jar) for several hours, fails to impair its efficacy, as tested by subsequent inoculation. 2°. That pure lymph mixed with an equal volume of the *aqua oxymuriatica*† of the Prussian Pharmacopœia, yields normal vesicles when inoculated. 3°. That lymph similarly treated with impure acetic acid was found to have lost its infective power. 4°. That out of eight children inoculated with lymph which had been mixed with commercial carbolic acid (proportions not given), only three took. The mixture is stated to have reddened blue litmus (?). The promise made by the author to publish an extended series of similar experiments does not, so far as I can ascertain, appear to have been redeemed.

Experiments performed by Dr. Dougall.

Dr. John Dougall, in the course of a very interesting experimental inquiry, published in the *Glasgow Medical Journal* for November 1872 and February 1873, performed 11 inoculations with vaccine which had been exposed to the action of certain volatile media. The method is thus described: "To the separate vapours (contained in bell-jars of a cubic "foot capacity) separate minims of vaccine lymph were exposed for "24 hours. The dry spot remaining was moistened with glycerine and "water, its reaction taken, and the mixture sealed in capillary tubes "till an opportunity occurred for vaccinating a child with it. All the "mixture was used in one insertion so as to make sure of obtaining its "full effect. The lymph in every instance was at first alkaline, and "the glycerine neutral." Inoculation yielded characteristic vesicles when performed with lymph which had been exposed to the action of the following vapours: carbolic acid, camphor, chloroform, sulphuric ether, and iodine. On the other hand the virus acted upon by chlorine, sulphur dioxide, nitrous acid, glacial acetic acid, and hydrochloric acid, proved absolutely barren. Dr. Dougall draws attention to the important circumstance that the mixture of lymph and glycerine, in every case in which it had retained infective power, was either alkaline or neutral; while in every case in which it had been successfully disinfected, its reaction was decidedly acid.

The general tenour of these results is in harmony with those arrived at in the course of the present inquiry. The apparent failure of carbolic acid is deserving, however, of a moment's consideration. Owing to an accident the vaccine was exposed to the carbolic vapour for 36 instead of 24 hours. The experiment was performed in hot weather (August). Somewhat surprised at the failure of so powerful an agent, Dr. Dougall

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[*] *Berlin. Klin. Wochenschrift*, 21 June 1869.

[†] This is a solution of chlorine, containing about ·4 per cent. of the gas.

inoculated some lymph to which one per cent. of the acid had been added; the inoculation was successful. In the writer's own words: "If "a minim of vaccine matter is unaffected after being buried for 36 hours "in the heart of a cubic foot of concentrated carbolic vapour, or after "being mixed with the acid *per se* in the proportion of 1 in 50 for "10 days, must not the highly attenuated carbolic vapour, alone attain- "able in practical aerial disinfection, of necessity be powerless to cope "with an atmosphere saturated and smelling with the contagium of "small-pox? Moreover, it is manifest that the comparatively small "quantity of the acid commonly used must in many cases fail to affect "the variolous poison, though incorporated with it by the sanitarian "brush in the usual manner." Of Dr. Dougall's two experiments, that in which diluted vaccine containing one per cent. of the acid produced a vesicle, coincides with the results arrived at during the present inquiry; but the failure of the concentrated carbolic vapour seems unaccountable in view of the results given in the last table. The discrepancy, however, does not suggest any difference of opinion on the part of the present writer as to the practical inutility of carbolic acid for purposes of aerial disinfection.

Henry's experiments on vaccine lymph.

Dr. Henry's experiments (*Philosophical Magazine*, vol. X., 1831) were solely intended to ascertain the disinfectant influence of heat on vaccine. As a brief series of similar experiments was performed in the course of the present investigation, it may not be amiss to recapitulate his results; for though few in number, and buried in an almost inaccessible volume, they have long served as the sole experimental basis of disinfection by means of dry heat.

1. Vaccine lymph on bits of glass was exposed to a temperature of 180° F. (82° C.) for four hours. Of three children vaccinated with this lymph none took the disease. They were all subsequently vaccinated with success.

2. Lymph heated for four hours to 120°–140° F. (49°–60° C.) was inoculated in two cases; neither took the disease.

3. Recent lymph heated from two to three hours to 160°–165° F. (71°–74° C.), proved ineffectual when inoculated.

4.

Lymph heated for	2	hours	at 150° F. (66° C.)	was found to have lost its infective power.
"	4	"	"	
"	2		at 172° F. (78° C.)	
"	4	"	"	

5. Lymph kept at a temperature of 120° F. (49° C.) for three hours was inoculated in two cases. Characteristic vesicles were produced in both.

Action of heat upon dried vaccine.

Ten inoculations were performed in the course of the present inquiry with dried lymph which had been exposed to heat. The following was the method pursued. A long mercurial thermometer with a cylindrical bulb was fitted into a large test-tube by means of a perforated cork, the bulb of the instrument being fixed in the axis of the tube and close to its lower end, but without touching its walls at any point. The test-tube was plunged into a water bath, and held in a vertical position by a clip. It was found possible, with a little care, to keep the temperature of the instrument nearly constant by varying the depth to which the tube was immersed in the bath. The apparatus was watched during the entire period of each experiment. Three points, folded in tissue paper, were tied on to the bulb of the thermometer in such a way that the charged extremity of each point was only separated from the surface of the bulb by one layer of the tissue paper. The time at which the tube was introduced into the bath was noted, also the moment at which the mercurial column reached the minimum and the maximum temperatures within which the exposure was meant to be restricted; also the moment of removal. The heated points were used to inoculate three places on one arm; three other points, charged with lymph from the same source, were used to inoculate the corresponding places on the opposite arm.

Action of Heat upon Dry Vaccine.

(Duration of Exposure in each Experiment 30 minutes.)

No.	Maximum and Minimum limits of Temperature to which the Points were exposed. (Centigrade.)	The same in Fahrenheit degrees.	Introduced into Hot Chamber at	Temperature reached Minimum at	Temperature reached Maximum at	Removed at	Result.	
							Arm inoculated with Virgin Points.	Arm inoculated with heated Points.
1	57° – 59°	134·6° – 138·2°	1·10	1·19	1·21	1·49	2	2
2	60° – 63°	140° – 145·4°	12·9	12·12	12·15	12·42	3	3
3	63° – 66°	145·4° – 150·8°	12·47	12·49	12·51	1·20	2	3
4	67° – 70°	152·6° – 158°	4·40	4·43	4·44	5·12	2	1
5	69° – 74°	156·2° – 165·2°	4·42	4·47	4·51	5·17	3	3
6	75° – 80°	167° – 176°	11·34	11·51	11·58	12·21	3	3
7	85° – 90°	185° – 194°	12·47	12·54	12·56	1·24	Did not return.	
8	85° – 90°	,, ,,	1·51	2·7	2·11	2·37	3	0
9	90° – 95°	194° – 203°	4·15	4·28	4·33	4·58	2	0
10	90° – 95°	,, ,,	12·45	12·49	12·54	1·19	3	0

These results seem, at first sight, to differ from those obtained by Henry. The virulence of lymph was destroyed in his experiments at lower temperatures (49°–60° and 66°). The all but certain explanation of the difference is to be sought in the length of exposure. In the first instance (49°–60°), the vaccine was heated during four hours, in the second (66°), for two hours, while in the present series the exposure never lasted more than 30 minutes. The probability of this explanation is enhanced by the fact which has been noticed more than once, and recently confirmed by Roberts (Studies on Biogenesis, *Philos. Trans.*, 1874, part II.), that the destruction of the germs of septic microzymes by heat may be adequately accomplished, either by brief exposure to high temperatures, or by more prolonged exposure to lower ones; in short that degree of heat and length of exposure are mutually compensatory.

Davaine's researches on the effect of heat in destroying the activity of charbon virus.

In connexion with this part of the subject, Davaine's researches* on the effect of heat in destroying the infective power of the virus of *charbon* (malignant pustule) are deserving of notice. He has ascertained that the guinea-pig is peculiarly susceptible (much more so than, *e.g.*, the rabbit) to the action of this virus, when taken from a bovine animal suffering from the disease. $\frac{1}{1000}$ or even $\frac{1}{1000000}$ of a drop of blood from such an animal, when introduced into the subcutaneous areolar tissue of a guinea-pig, causes the speedy death of the latter, without any signs of local irritation. Such fractional doses are obtained by diluting a drop of blood with a known volume of water.

The virus after exposure to heat was invariably tested by inoculation into guinea-pigs. The following is a brief summary of the results:—

Exposure of the virulent blood diluted with an enormous excess of distilled water to a temperature of - -	55° C. disinfects it in 5 minutes.
	48° C. ,, 15 minutes.
	50° C. ,, 10 minutes.

When the blood is not diluted, its complete disinfection requires an exposure to 51° C. for 15 minutes. If the blood be previously dried over calcium chloride, and then heated to 100° C. for five minutes, its virulence is found not to be impaired.

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* *Comptes Rendus*, 29 September 1873.

These results confirm the statement already made that degree of heat and length of exposure are mutually compensatory. Further, they draw attention to the fact that differences in the physical condition of the virus,—in the nature of the medium in which its particles are suspended,—alter its susceptibility to disinfection by heat in a very striking way.

III. EXPERIMENTS WITH THE VIRUS OF INFECTIVE INFLAMMATION.

Virus of infective inflammation compared with the specific contagia.

The points of resemblance and difference between the virus of infective inflammation in rodents and the specific contagia of cow-pox and glanders have already been alluded to. The only essential difference between them was seen to be that whereas the latter cannot, by any means at present known to us, be generated anew, the former can be produced at will by introducing inflammatory products of any sort, or even chemical irritants, into the peritoneal cavity of a healthy animal, and employing the exudation-liquid resulting from the peritonitis for the inoculation of other animals. The pathology of the disorder has been fully discussed in the Medico-Chirurgical Transactions for 1873; it will not be necessary, therefore, to give any detailed account of it in this place. Some particulars, however, concerning the mode in which the virus was prepared, the effects to which it gave rise, and the method employed in testing tho action of disinfectants upon it, are needed by way of introduction to the tabular summary of the experiments themselves.

Sources from which it was derived.

The virus was invariably derived from the peritoneal cavity of guinea-pigs which had succumbed to infective peritonitis. This peritonitis was sometimes primary, sometimes secondary; when primary, it was excited by the introduction of putrid pus, or of exudations from dogs which had died of artificial septicæmia, or of peritoneal exudation from other guinea-pigs, into the abdominal cavity; when secondary, it was a result of the subcutaneous inoculation of infective products derived from other guinea-pigs. The material employed had thus passed, now through one, now through several generations of animals; and though, as is well known, the virulence of the latter is much more intense than that of the former, it was not observed that there was any difference between them as regards their susceptibility to the action of disinfectants.

Its physical and chemical characters.

The physical and chemical characters of the virus were not always the same; it was commonly pale and viscid, occasionally sanguinolent and watery. It was always crowded with microzymes in the form of spheroids, dumb-bells, and necklaces; few or no rod-like bacteria were observed; and none of the organisms exhibited movements of translation. Notwithstanding the usually viscid and tenacious character of tho material, it was found to contain but little solid matter. An analysis performed by Mr. Duguid shewed its sp. gr. to be 1019·3; when dried at 100° C. it left 5·0118 per cent. of solid residue, and this, on incineration, yielded ·793 per cent. of ash. In reaction it was always neutral or feebly alkaline.

Method of experimentation.

The degree of dilution of the virus employed varied within considerable limits; the amount of viscid exudation was sometimes so small that in order to obtain sufficient material for a series of inoculations it was necessary to wash out the peritoneal cavity with saline solution, and to add tho washings to the unmixed liquid. The dose inoculated, though always small, was also not invariably the same. No surer proof of the genuine virulence of the liquid can be given than this, that whatever the dose, or the degree of dilution (within very wide limits), it either produced its full specific effect, or no effect at all. It is right to add, however, that in each individual series of experiments, virus from the same source, diluted to the same extent, and in exactly the same dose, was injected into each of the animals. Further, that in every series the virulence of the unmodified liquid was established by a control experiment.

Guinea-pigs were employed in preference to rabbits for several reasons. A number of experiments made on rabbits turned out to be valueless owing to the very capricious and uncertain tenure on which these rodents hold their life. Some die suddenly without apparent cause; others survive the inoculation of liquids which prove rapidly fatal to their fellows; and the accidental death or survival of any one animal out of a series vitiates the result of the series as a whole. Again, the rabbits which succumb do not exhibit very definite structural lesions, so that it is often impossible to say whether a given animal has died in consequence of inoculation, or from some collateral and unknown cause. Guinea-pigs are more hardy; they do not commonly die without appreciable cause; and the inoculation of virulent liquids produces in them tolerably definite and constant structural alterations.

Lesions resulting from successful inoculation.

The lesions resulting from the injection of minute quantities of the above-described virus into the subcutaneous areolar tissue of the guinea-pig are never co-extensive with the tract of tissue presumably infiltrated with the liquid introduced; they either spread far beyond its limits, or else involve secondarily the great serous cavities. The appearances noticed may be roughly grouped under one or other of the following heads:—

1. The subcutaneous areolar tissue over a very large portion of the body is infiltrated with a thin, reddish, fetid liquid, swarming with microzymes; the skin is thus detached from the underlying parts and may become necrosed; the muscles are often discoloured and friable, looking as if macerated. Internal inflammations are absent.

2*a*. With a variable, though never very considerable, degree of local inflammation, there are all the signs of peritonitis; the intestines more or less glued together, the liver smeared with yellowish lymph, perhaps adherent to the diaphragm. A quantity, usually small, of viscid exudation, crowded with microzymes, occupies the most dependent part of the abdominal cavity.

2*b*. In addition to the peritonitis, similar marks of inflammation are seen in one or both pleuræ, and in the pericardium.

No very definite conclusions were arrived at concerning the immediate cause by which the occurrence of one set of appearances rather than of another was determined. One point stood out clearly, viz., that the difference in degree and character of the inflammatory changes was associated with some peculiarity of the material inoculated, and not with any idiosyncrasy of the animals. Virus from the same source always caused appearances of the same kind; and the existence of very extensive cellulitis was always found to coincide with the absence of serous inflammations. When the serous membranes were involved, the peritoneum was always the first to suffer; the pleurisy and pericarditis being always subsequent in the order of their evolution.

Tabular view of experiments performed.

The following table gives a summary view of the results obtained by allowing the four disinfectants to act on the virus. The length of time during which the virus was exposed to their influence varied from 30 minutes to three hours; this point appeared unimportant, since it was found that the action could be effectually completed within five minutes, provided that thorough mixture had been insured. The inoculations were invariably performed in the subcutaneous tissue on one side of the body; the point of a Pravaz's syringe being pushed through the skin half an inch from the spinous processes of the vertebræ, and passed downwards for about an inch.

Series.	No. of Animal.	Weight of Animal in grammes.	Date of Inoculation.	Material inoculated.	Dose.	Proportion of disinfectant Agent in the inoculated Material.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
I.	1	415	October 23	Virus diluted with its own volume of ½ per cent. saline solution. The virus was freshly taken from the abdomen of a guinea-pig which died after the introduction of 3 minims of Cohn's solution, swarming with microzymes, into the peritoneal cavity; double pleurisy and pericarditis were found associated with the peritonitis. The exudation-liquid was yellowish and viscid, and full of microzymes.	4 ♏	0	36 hours	No local changes at site of inoculation visible to the naked eye. Peritoneal cavity contained a small quantity of viscid, yellowish exudation, crammed with organisms. Both surfaces of liver, under surface of diaphragm, and spleen, smeared with flaky lymph. No pleurisy or pericarditis.
	2	385	Do.	Same virus mixed with equal volume of 4 per cent. solution of carbolic acid.	4 ♏	2 per cent. carbolic acid.	- - -	No symptoms. Quite healthy on November 14.
	3	409	Do.	Same virus mixed with equal volume of 2 per cent. solution of carbolic acid.	4 ♏	1 per cent. carbolic acid.	- - -	No symptoms. Used for another experiment on January 16.
II.	4	428	February 2	Virus mixed with equal volume of saline solution. The virus was taken from the abdomen of a guinea-pig which died of peritonitis, caused by the introduction of putrid pus into its peritoneal cavity. It had been kept in a sealed tube in the laboratory (at a temperature of 60° – 65° F.) for several days.	5 ♏	0	- - -	None of the animals in this series showed any symptom of illness. The inoculated material was putrid. The animals were all employed again in other experiments, an opportunity being thus afforded of ascertaining that the present inoculation had left no visible traces.

Series.	No. of Animal.	Weight of Animal in grammes.	Date of Inoculation.	Material inoculated.	Dose.	Proportion of disinfectant Agent in the inoculated Material.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
II.	5	388	February 2	Same virus mixed with equal volume of 2 per cent. solution of carbolic acid.	5 ♏	1 per cent. carbolic acid.	- - -	No effect.
	6	390	Do.	Same virus mixed with equal volume of 1 per cent. solution of carbolic acid.	5 ♏	·5 per cent. carbolic acid.	- - -	No effect.
III.	7	596	February 9	Virus mixed with equal volume of saline solution. The material was a sanguinolent exudation from the peritoneum of a guinea-pig; the peritonitis had been caused by injection of similar exudation from another guinea-pig into the abdominal cavity. Had been kept in a sealed tube, embedded in ice, for two days.	5 ♏	0	24 hours	Succumbed to an acute cellulitis of great intensity. The skin was detached from the underlying tissues over the greater part of the thorax and abdomen by a thin, fetid, sanguinolent liquid, crowded with organisms. The abdominal muscles were pale, sodden, and friable. No signs of inflammation in the serous cavities.
	8	573	Do.	Same virus mixed with equal volume of 2 per cent. solution of carbolic acid.	5 ♏	1 per cent. carbolic acid.	- - -	No symptoms. Used again on March 2. It was then observed that the site of the present inoculation was marked by a small patch of thickening, about the size of a split pea.
	9	512	Do.	Same virus mixed with an equal volume of 1 per cent. solution of carbolic acid.	5 ♏	·5 per cent. carbolic acid.	40 hours	Same appearances as in 7. Moreover, the parietal layer of peritoneum was intensely injected, and studded with minute extravasations.

App. No. 6.

On Disinfectants, by Dr. Baxter.

Series.	No. of Animal.	Weight of Animal in grammes.	Date of Inoculation.	Material inoculated.	Dose.	Proportion of disinfectant Agent in the inoculated Material.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
IV.	10	343	March 4	Virus mixed with an equal volume of saline solution. The virus was a viscid, pale liquid from the abdomen of a guinea-pig which died of infective peritonitis in 18 hours. The peritonitis was set up by the injection into the peritoneal cavity of two drops of a sanguinolent exudation from the belly of a dog which succumbed in seven hours to the most acute form of septicæmia. This had been caused by injection into its veins of an excessively virulent exudation procured by transmission through a series of guinea-pigs.	4 ♏	0	Killed on March 16	At site of inoculation an abscess as big as a cherry, filled with curdy pus; lymphatic glands in the neighbourhood of the scapula considerably swollen. Secondary deposit in one lung.
	11	375	Do.	Same virus mixed with an equal volume of 2 per cent. solution of carbolic acid.	4 ♏	1 per cent. carbolic acid.	- - -	No effect.
	12	393	Do.	Same virus mixed with an equal quantity of 1 per cent. solution of carbolic acid.	4 ♏	·5 per cent. carbolic acid.	18 hours	Slight ecchymosis at site of puncture; no cellulitis. Scanty, colourless, very viscid exudation in peritoneal cavity, crowded with organisms. No flakes of lymph. No pleurisy or pericarditis.

Series.	No. of Animal.	Weight of Animal in grammes.	Date of Inoculation.	Material inoculated.	Dose.	Proportion of disinfectant Agent in the inoculated Material.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
V.	13 Rabbit.	1,387	November 26	Virus mixed with equal parts of saline solution. Virus taken from peritoneum of guinea-pig, No. 31. Had been preserved in ice (in a sealed tube) for 16 days.	2½ ♏	0	48 hours	Subcutaneous tissue at site of inoculation slightly œdematous, and paler than surrounding parts. Some minute petechiæ on peritoneal covering of intestines. No other lesion observed.
	14 Rabbit.	1,004	Do.	Same virus mixed with equal parts of 2 per cent. solution of carbolic acid.	2½ ♏	1 per cent. carbolic acid.	- - -	In excellent health on January 20, when it was used for another experiment; no signs of present inoculation to be seen.
VI.	15	549	November 17	Virus mixed with equal quantity of saline solution. Virus derived from peritoneum of guinea-pig, No. 27. Had been kept in a sealed tube, in the laboratory, for 13 days.	2½ ♏	0	- - -	In perfect health on January 16. The virus, kept during 13 days in a sealed tube, appears to have lost its infective power.
	16	462	Do.	Virus mixed with equal volume of solution of sulphur dioxide.	2½ ♏	·736 per cent. SO_2	- - -	No symptoms. Used again on January 16.
	17	371	Do.	Ditto - - -	2½ ♏	·2453 per cent. SO_2	- - -	No symptoms. Used again on January 16.
VII.	18	486	February 9	Same virus as that used for inoculating No. 7 (see *ante*), mixed with equal volume of saline solution.	5 ♏	0	24 hours	Same appearances as in No. 7.
	19	587	Do.	Same virus mixed with equal volume of solution of sulphur dioxide.	5 ♏	2·9 per cent. SO_2	- - -	Used again on March 2. No symptoms.
	20	380	Do.	Ditto - - -	5 ♏	·58 per cent. SO_2	40 hours	Diffuse cellulitis, as in No. 7.

App. No. 6.

On Disinfectants, by Dr. Baxter.

Series.	No. of Animal.	Weight of Animal in grammes.	Date of Inoculation.	Material inoculated.	Dose.	Proportion of disinfectant Agent in the inoculated Material.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
VIII.	21	299	November 14	Virus mixed with equal volume of saline solution. Taken from peritoneal cavity of guinea-pig No 30. Pale, viscid, neutral. Not fetid.	$2\frac{1}{2}$ ♏	0	48 hours	Hardly a trace at site of inoculation. Scanty, colourless, very viscid exudation in abdominal cavity, crowded with microzymes. No pleurisy or pericarditis.
	22	560	Do.	Same virus mixed with equal volume of chlorine solution. The mixture was distinctly acid, and contained free Cl., as shewn by iodide of potassium and starch.	$2\frac{1}{2}$ ♏	·1563 per cent. Cl.	- - -	No symptoms. Died on December 12, after sudden onset of severe cold. No trace of inoculation, or of its specific effects, to be seen. No serous inflammation.
	23	385	Do.	Ditto - - -	$2\frac{1}{2}$ ♏	·07815 per cent. Cl.	- - -	No symptoms. Used again on January 16.
IX.	24	805	February 16	Virus, one part; saline solution, two parts. Same material as that with which No. 7 was inoculated. Had been kept in a sealed tube (in ice) for nine days.	5 ♏	0	36 hours	Same appearances as in No. 7.
	25	388	Do.	Virus, one part; saline solution, one part; solution of potassic permanganate, one part -	5 ♏	·1 per cent. of permanganate.	- - -	No symptoms.
	26	810	Do.	Ditto - - -	5 ♏	·05 per cent of permanganate.	- - -	No symptoms.

App. No. 6.

On Disinfectants, by Dr. Baxter.

Results obtained.

It appears, as a result of the above experiments, that carbolic acid in the proportion of 1 per cent. or more, chlorine in that of ·078 per cent. or more, sulphur dioxide in that of 2·9 per cent. or more, and permanganate in that of ·05 per cent. or more, are capable of so modifying the virus as to deprive it of all infective power. It should be noted that in the solutions disinfected with chlorine, the presence of this gas in a free state was always shewn by potassic iodide and starch after mixing had been completed; and that the liquids containing SO_2 were decidedly acid in reaction. Further experiments with the same virus will be described in the concluding section of the report.

The researches of Davaine[*] upon the action of disinfectants on the virus of *charbon*, and those of Rosenbach[†] on the influence of carbolic acid in preventing pyæmic and putrid infection, furnish results which may be usefully compared with the above.

Davaine on the action of disinfectants on charbon virus.

Davaine employed the blood of an animal suffering from malignant pustule, diluted with 100 parts of water, for inoculating guinea-pigs, which are peculiarly susceptible to the action of this virus (*Cf.* p. 14). The virulent liquid was mixed with a solution of the disinfectant, and allowed to stand from 30 minutes to an hour before being inoculated. Death resulted from the hypodermic injection of minute quantities of the liquid, when its activity had not been destroyed, in from one to four days; sometimes, though rarely, the guinea-pigs survived till the eighth day. These points indicate a very considerable degree of resemblance between the effects of the *charbon* virus and those produced by the infective products employed in the present investigation.

A number of disinfectants were tested; singularly enough, chlorine and sulphur dioxide were not included in the list. The best results were furnished by iodine, which destroyed the infective property of the liquid in the proportion of ·0083 per cent. Chromic and sulphuric acid, though inferior to iodine, stood higher than potassic permanganate and carbolic acid. When the permanganate was added to the virus in the proportion of ·1, ·08, ·0333, ·02, per cent., inoculation was followed by recovery; ·0166 per cent. was found ineffectual. Carbolic acid, when present in the proportion of 1 per cent. or more, destroyed the virulence of the liquid; ·5 per cent. failed to do so; one experiment with virus containing ·75 per cent. of the acid ended in the recovery of the animal.

These results are in obvious agreement with those derived from the experiments performed with the virus of infective inflammation, and differ widely from those furnished by vaccine. The probable explanation of this discrepancy will be considered in the concluding section of the report.

Rosenbach's experiments on the disinfectant power of carbolic acid.

Rosenbach's inquiries were limited to the action of carbolic acid on pus. They deserve mention in this place chiefly because the method employed to determine the effect of the acid was that on which we have insisted as the only right one: the disinfected material being inoculated on a living animal, and the result compared with that due to the inoculation of the same material prior to the admixture of any disinfectant.

Three varieties of pus were employed for inoculation. The first series of experiments was conducted with pus which had undergone decomposition in the body before its removal; the second with pus which was perfectly fresh when removed from the body, but which had been subsequently allowed to putrefy; the third series comprised inoculations with fresh (non-putrid) pus drawn from acute abscesses. The animals inoculated were rabbits and dogs, and the material was always introduced into the subcutaneous tissue in comparatively large quantities (5—15 c. c.). The infective character of the liquid manifested itself by causing diffuse phlegmonous inflammation, spreading from the inoculated spot, and proving rapidly fatal; when this primary effect was less intense the animals either recovered, or succumbed to secondary mischief of a pyæmic kind. The appearances were by no means constant; and this lack of uniformity is intelligible enough when we consider the very uncertain character of the materials employed for inoculation.

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[*] *Comptes Rendus*, 13 October 1873.

[†] *Untersuchungen über den Einfluss der Carbolsäure gegen das Zustandekommen der pyämischen und putriden Infektion bei Thieren.* Göttingen, 1872.

The presence of 5 per cent. or more of pure carbolic acid in the inoculated material rendered it harmless; 1 per cent. was uncertain in its effect; smaller quantities were always ineffectual. The acid was found to be less powerful in its effect on pus which had been allowed to putrefy outside the body, than on pus which was already fetid when discharged. These results, though not opposed to our own, are vitiated—as regards the purpose in hand—partly by the very uncertain nature of the material used, partly by the indiscriminate employment of animals so different in their susceptibility as dogs and rabbits, and finally by the capricious variety of the symptoms and morbid changes produced.

IV. Experiments with the Virus of Glanders.

Although the following experiments performed with the infective material of glanders are neither so numerous, nor, with one exception, so convincing as those already described, it has been thought desirable to place them on record, partly because no similar trials have hitherto been made; partly because any observed facts relating to a disease at once profoundly interesting, and, considering its frequency, so little studied, have in themselves a positive worth apart from the immediate object for which they have been sought.

Nature and properties of the virus of glanders.

There are two more particular reasons why the virus of glanders should commend itself to the notice of those engaged on such an inquiry as the present one. In the first place, it is one of the few acute specific diseases to which man is liable in common with certain of the lower animals. In this respect it stands upon a different footing from cattle-plague or ovine variola. Ever since the disease was recognised in the human subject by Elliotson in this country, by Rayer in France, similar cases have annually been noticed and put on record. Secondly, the nature of the infective material has been subjected by Chauveau and others to an investigation similar in method, and furnishing similar results, to that pursued in reference to the contagia of cow-pox, small-pox, and variola ovina. It has been proved that the contagious principle of glanders is neither soluble, nor diffusible, nor volatile; and that by inference it must consist of minute solid particles. The nature of these particles in this case, as in the others, is still open to question. There is no proof that they are capable of being generated otherwise than in a previously infected organism; and there is abundant evidence to prove that when introduced in the most minute quantity into a suitable medium, they undergo multiplication to an enormous extent, and with enormous rapidity. The morbid product of the glanderous process has thus the distinctive mark of a virus, and of a specific virus; specific, inasmuch as it cannot be produced *de novo* by any means now known to us, and is not inoculable on all animals indiscriminately; the horse, the ass, and the human subject being readily susceptible to its influence, while it does not seem to produce any effect upon the rabbit.

Preparation of the virulent liquid.

The virulent material employed in the first series of inoculations was prepared as follows. The nodules of infective pneumonia in the lung of a horse labouring under acute glanders, and which had just been killed, were cut out with scissors and bruised in a mortar with the addition of a small quantity of half per cent. saline solution. The nodules varied in size from a pea to a walnut; they were of a yellowish-grey tint, firm, and somewhat elastic. The creamy liquid, full of shreds of tissue, which was thus obtained, was filtered through a double fold of muslin. The filtered material was of a bright red colour owing to admixture of blood, neutral to test-paper, and coagulable by heat and nitric acid. Under the microscope it was seen to contain a vast number of shrunken and distorted red blood-corpuscles, epithelium cells, and other tissue-elements; besides these, a multitude of extremely minute, highly refracting, motionless spheroids, but no locomotive microzymes. When the liquid was allowed to stand, an abundant sediment of a dirty red colour formed at the bottom of the glass; it consisted of the corpuscular elements enumerated above.

Method of experimentation adopted in Series A.

It was anticipated that the local phenomena produced by the inoculation of this liquid would manifest themselves with sufficient distinctness before the general invasion of constitutional disturbance, to enable a number of inoculations to be simultaneously carried out on the same animal. In an inquiry which involved repeated inoculations, and which could only be conducted on large animals, such as horses or donkeys, this was the only practicable course. The issue of the first series of experiments showed, however, that this method, though yielding results of a considerable degree of probability, was nevertheless open to objection on the score of uncertainty.

The infective liquid described above was divided into two equal parts. One of these was put aside (I). The other was washed with half per cent. saline solution so as to separate its solid constituents, as far as possible, from the soluble matters with which they were mingled. The washing was carried out as follows: a large excess of saline solution having been added to the liquid, the two were shaken up together, and the mixture set aside in several tall narrow test-tubes; after a couple of hours the supernatant liquid was removed from each tube by a siphon, without disturbing the sediment. Fresh saline solution was then poured into each tube and the process repeated. This was done six times, and the resulting sediments were then collected in a single tube. They formed a flocculent stratum of a dirty-white colour, the supernatant liquid being only slightly turbid; heat and nitric acid caused a doubtful increase of this turbidity, but threw down no precipitate. This almost aqueous liquid, holding a number of whitish flocculi in suspension, will be denominated (II).

It had already been shewn by Chauveau, though for another purpose altogether, that the solid elements of a mixture holding the infective material of glanders in suspension could be separated by repeated washing and decantation from the soluble compounds with which they were associated, and that the washed residue retained its infective power. The operation was meant in the present instance to furnish a virulent liquid containing a minimum of such organic and mineral constituents as might be expected to influence the action of disinfectant agents; in short, to replace the complex medium in which the contagium was suspended, as thoroughly as might be, by saline solution.

The portion of virulent liquid marked (I) was then distributed into five

Disinfectants employed in this series of inoculations.

tubes, each of which was made to contain 2 c.c. of it. The following additions were then made to the contents of the several tubes :—

1. To this was added an equal volume of saline solution.

2. Was mixed with 2 c.c. of a freshly made two per cent. solution of carbolic acid.

3. Mixed with 2 c.c. of ·1 per cent. solution of potassic permanganate.

4. Mixed with 2 c.c. of solution of sulphur dioxide (containing 3·88 per cent. of the gas).

5. Mixed with 2 c.c. of a weaker solution of sulphur dioxide (containing ·518 per cent).

The permanganate in 3 was quickly decolorized; the two solutions containing sulphur dioxide were instantly blackened. 1 and 2 shewed no change of colour.

2 c.c. of the portion of liquid marked (II) were then introduced into each of three tubes.

The following additions were made :—

6. To this 2 c.c. of saline solution were added.

7. Mixed with an equal volume of 2 per cent. solution of carbolic acid.

8. Mixed with an equal volume of ·1 per cent. solution of potassic permanganate.

The eight mixtures thus prepared were then introduced into tubes drawn out at each end into capillary extremities, and sealed up. The tubes were preserved in ice. The following table gives at a glance the proportion of disinfectant contained in each of the liquids :—

1.	Not washed.	No disinfectant.
2.	Do.	Carbolic acid, 1 per cent.
3.	Do.	Potassic permanganate, ·05 per cent.
4.	Do.	Sulphur dioxide, 1·94 per cent.
5.	Do.	do. ·259 per cent.
6.	Washed sediment.	No disinfectant.
7.	Do.	Carbolic acid, 1 per cent.
8.	Do.	Potassic permanganate, ·05 per cent.

Series A.

On January 11, 24 hours after the above liquids had been prepared, an old healthy male donkey (hereafter to be known as M) was inoculated in eight places. Four patches of skin had previously been shaved on each side of the trunk; they were nearly equidistant from one another, the first of each series being on the shoulder, the last close to the thigh. The animal had been kept under observation for eight days, and his temperature had been taken daily in the rectum. The mean of these eight observations was 100·2° F.

The inoculations were performed by plunging the nozzle of a hypodermic syringe into the subcutaneous areolar tissue, and injecting 10 minims of the liquid. After each inoculation, the syringe was thoroughly washed with saturated solution of carbolic acid, and then with water. Each of the eight patches accordingly received 10 minims of one of the eight liquids enumerated above. The injection did not seem to cause the animal any annoyance, except in the case of the solutions containing sulphur dioxide, which were decidedly acid.*

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* The inoculations were performed and the symptoms observed by Mr. Duguid, veterinary surgeon to the Brown Institution, to whose familiarity with the disease, and cordial co-operation, this set of experiments owes whatever value it may be found to possess.

Record of symptoms.

The following is a brief record of the progress of the case. The numbers correspond to those of the liquids introduced :—

Jan. 12.	T—101·3° F.	Some thickening to be felt in all of the inoculated spots.
„ 13.	T—104·3.	Patch 1 discoloured, hot and tender.
„ 14.	T—103·2.	
„ 15.	T—104·8.	Swelling extending downwards to the knee, forwards to the sternum.
„ 16.	T—104.	
„ 17.	T—104·2.	
„ 18.	T—104·6.	Small bullæ have made their appearance over patch 1.
„ 19.	T—105.	Copious discharge from right nostril. Small farey-bud on right upper lip. Chain of nodules extending along course of jugular vein from patch 1. Other nodules can be felt elsewhere under the skin, chiefly, but not exclusively, in the vicinity of the inoculated patches.
„ 20.	T—104.	Refuses food. Breathing laboured and stertorous.
„ 21.		Farey-buds scattered about the body. Scrotum and testes much swollen.
„ 22.		Found dead this morning. Post-mortem examination made several hours after death. The following is a brief summary of its results :—

Post-mortem appearances.

The skin over patch (1) was black, and seemed on the point of sloughing. The patch of skin corresponding to (6) was distinctly indurated, and the neighbouring lymphatics were corded. The remaining six patches were for the most part free from any decided change, except a little subcutaneous thickening. But in the immediate neighbourhood of almost all of them one or more subcutaneous nodules could be felt. Similar nodules, however, were irregularly distributed under the skin in parts remote from the site of any inoculation. When the skin was removed, the tissues under (1) were found to be gangrenous; the entire thickness of the muscles having been converted into a putrid mass of reddish-yellow material, breaking down at its centre into a fetid ichor. The site of (6) was occupied by a large deposit of caseous material softening at its centre; the areolar tissue round it was dotted with extravasations. Yellowish nodules and patches of capillary ecchymosis were found in the immediate vicinity of every one of the inoculated spots; but similar nodules and patches existed all over the body; the utmost one could say was that the nodules were more closely aggregated and more numerous near the site of the inoculations than elsewhere. The subpleural and subpericardial tissue was everywhere studded with minute petechiæ. Nodules of infective pneumonia were scattered throughout both lungs, which were intensely œdematous. The trachea and bronchi were full of frothy secretion; on splitting open the nostrils, the mucous membrane was found congested in patches; a few nodules resembling miliary tubercles were seen in the submucous tissue; no ulceration had as yet taken place. Both testicles were much swollen, and contained secondary deposits; the left one was almost black from intense congestion.

These appearances were amply sufficient to shew that the animal had succumbed to the most virulent form of acute glanders, and that the inoculated liquids 1 and 6 had started the disease. But the invasion of constitutional infection had been too rapid and violent to allow the local phenomena consequent upon inoculation to develope themselves freely ; the primary and the secondary lesions had manifested themselves almost simultaneously, and there was an obvious difficulty in deciding to which of the two categories any particular subcutaneous lesion ought to be assigned. In the first place, however, there was a very marked difference, both qualitative and quantitative, between the changes observed in (1) and (6), and those detected in the remaining patches ; secondly, the nodules and hæmorrhagic maculæ in these latter patches were identical with others situated in parts far removed from the site of any inoculation. For these reasons, it seemed highly probable that the lesions observed in all the patches except (1) and (6) were really part of the secondary process, products of constitutional infection ; and their presence in greater number in the neighbourhood of the inoculated spots was attributed to the local irritation caused by the chemical nature of the materials injected, just as an exanthem is more abundantly localized in the neighbourhood of a wound or other focus of irritation than elsewhere.

Inferences from the experiment.

To sum up, the virulent liquid *appears* to have been deprived of its infective power by the addition of 1 per cent. of carbolic acid, ·05 per cent. of potassic permanganate, 1·94 per cent. and ·259 per cent. of sulphur dioxide ; and, in these proportions, the disinfectant agents seem to have acted as effectually upon the unwashed as upon the washed virus.

Series B.

Method adopted in Series B.

In order to obtain results free from the possible objections to which those in series A are liable, it was resolved to inoculate only one place at a time, allowing a week to elapse after each inoculation ; the absence of any rise of temperature or other untoward symptom during this interval affording sufficient proof of the harmless nature of the material inoculated. A large supply of virus was prepared, in the manner already described, from the infective nodules in the lungs of the last donkey. It was preserved in hermetically sealed glass tubes.

Experiment with carbolic acid.

A young, healthy, male donkey (N), was kept under observation for several days, and his mean temperature was ascertained to be 100° F. On January 25, 10 minims of the following mixture were injected into the subcutaneous areolar tissue over the left shoulder ; virus diluted with an equal volume of a 4 per cent. solution of carbolic acid. The temperature rose on the third day after inoculation to 102° F., and the inoculated spot was hot and tender. On the ensuing day, however, the temperature had fallen to 100° F., where it remained ; the tenderness and swelling gradually disappearing in the course of the next few days.

With sulphur dioxide.

On February 4, a second inoculation was performed on the right shoulder. The virus was mixed with its own volume of a solution of sulphur dioxide, containing 2·88 per cent. of the gas ; the mixture was strongly acid, and of a blackish colour ; 10 minims were injected. The acid liquid caused considerable swelling and tenderness, which took several days to subside. The temperature never rose at all.

With carbolic acid and chlorine.

A new donkey (old, male) having been obtained (O), the two animals were inoculated simultaneously on Febuary 11. N received 10 minims of a mixture of equal parts of the virus and 2 per cent. solution of carbolic acid ; while O was inoculated with the same quantity of a mixture of equal parts of the virus and Chlorine solution (containing ·3266 per cent. of the gas).

The addition of carbolic acid turned the virulent liquid of a brighter red ; its reaction continued neutral. Under the influence of chlorine, its colour changed to a dirty bottle-green; the mixture being decidedly acid, and containing free chlorine (as shewn by potassic iodide and starch). The result of the two experiments is shewn in the following table:

N. (Normal Temperature, 100° F.	O. (Mean Temperature before Inoculation 100° F.)
Feb. 12. T.–103·2. Inoculated spot swollen, hot, tender, and slightly discoloured.	Feb. 12. T.–100·2. A small hard nodule can be felt at the site of inoculation. Not tender.
„ 13. T.–103. Swelling is extending.	„ 13. T.–100·4.
„ 14. T.–100·8.	„ 14. T.–99·8.
„ 15. T.–100·8. Swelling and tenderness are subsiding.	„ 15. T.–100·4.
„ 16. T.–100·4.	„ 16. T.–100·2. Nodule has disappeared.
„ 17. T.–100·3. Swelling has nearly disappeared.	„ 17. T.–99·8.
„ 18. T.–100·2.	„ 18. T.–99·8.

Putrefaction of virulent liquid.

The rise of temperature and local disturbance which occurred in N. are phenomena difficult of explanation. For three days after the animal had been inoculated, it was believed that the inoculation had proved effectual; but the untoward symptoms passed off as rapidly as they had set in. On February 18, N. and O. were again inoculated; but it was noticed that the virulent liquid had a decidedly putrid odour, very different from the faint animal aroma which it had previously given off. The tubes, owing to a deficiency in the supply of ice, had been kept in the open air, the weather being very cold. A sudden thaw, which lasted for two or three days, had evidently allowed their contents to undergo decomposition. No result having been noticed to follow the two inoculations on February 18th, 10 minims of unmixed virus were injected into N. on the 23rd; no symptoms followed, with the exception of slight local tenderness.

Inferences from this series of inoculations.

The control experiment having thus proved a failure, any deductions from the experiments belonging to this series must necessarily rest upon the assumption that up to and including February 12, the virulent liquid had retained its infective properties. In favour of this assumption we have the facts that the liquid, up to that date, had been exposed to a very low temperature and had shewn no sign of putrefactive change;* also that it gave rise to anomalous, but marked symptoms after its admixture with 1 per cent. of carbolic acid. Still, the following results, however probable, are not absolutely certain; namely, that the presence of 2 per cent. of carbolic acid, of 1·44 per cent. of sulphur dioxide, of ·1633 per cent. of chlorine deprived the virulent liquid of its specific properties; and that although the presence of 1 per cent. of carbolic acid annulled its specific infective power, it allowed it to produce local and general symptoms of a grave kind.

Series C.

Method followed in Series C.

A fourth donkey (P) having been obtained, whose fore-leg was irremediably damaged by an accident, but which was otherwise in good health, it was resolved to perform three inoculations at the same time, one on each of the three animals. Fresh material having been prepared

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* It was incidentally noticed in the course of the present enquiry, that putrefactive change, occurring in the virus of vaccine, in that of experimental septicæmia, and in that of glanders, appeared invariably to destroy their specific infective power.

App. No. 6.

On Disinfectants, by Dr. Baxter.

in the usual way from the pulmonary nodules of a horse suffering from glanders, the following experiment was carried out on March 4. N. received 10 minims of a mixture of the virus with an equal volume of 4 per cent. solution of carbolic acid; O, a similar quantity of a mixture of the virus with an equal volume of solution of sulphur dioxide (containing ·8 per cent. of the gas); P, 10 minims of a mixture of equal parts of virus and 1 per cent. solution of carbolic acid. The mixture containing SO_2 was strongly acid; the other two were neutral. The result of the three inoculations is given in the following table:

Record of symptoms.

N.	O.	P. (Mean Temperature before Inoculation 100° F.)
March 5. T–100. Small nodule, not tender, at site of injection.	March 5. T.–99·8. Slight thickening felt at inoculated spot.	March 5. T–100°. Inoculated spot slightly swollen and tender.
„ 6. T–100·2.	„ 6. T–100.	„ 6. T–100·2.
„ 7. T–100·2.	„ 7. T–100.	„ 7. T–102·6. Very tender.
„ 8. T–100·4. Nodule has disappeared.	„ 8. T–100·4.	„ 8. T–104·6. Skin hot and discoloured over injected patch.
No further symptoms or rise of temperature.	No further symptoms or rise of temperature.	„ 9. T–104·8. Animal appears decidedly ill.
		„ 10. T–103·8.
		„ 11. T–103·2. Refuses food. Corded lymphatics round swollen patch.
		„ 12. T–103·6. Tenderness very great; swelling travelling down leg; farey-buds appearing on the neck.
		„ 13. T–103.
		„ 14. T–103·2.
		„ 15. T–103. Discharge from nostrils. Breathing quick and laboured.
		„ 16. Found dead this morning.

Post-mortem Examination of P. on March 16.

Post-mortem appearances.

At the site of inoculation the skin is bound down to the deeper tissues by a patch of exudation, as large as a man's hand, studded with capillary hæmorrhages. The areolar tissue all down the corresponding leg is infiltrated with a serous liquid; distended and knotty lymphatics radiate from the affected spot. On cutting into the underlying muscles, a large ragged cavity is laid open, full of yellowish curdy pus; round this are scattered smaller deposits of a similar kind varying in size from a pea to a walnut. On stripping off the skin at a point about two feet away from the inoculated spot, a large yellowish nodule is discovered in the subcutaneous tissue; around it are innumerable capillary extravasations. (This lesion was situated at the point where a second inoculation would have been performed had the method employed in series A. been adopted in the present instance, and it might then have been attributed to a primary local infection.) A few similar deposits were noticed elsewhere. There was an absence of putridity about the primary lesion which contrasted markedly with the appearances in M.

On opening the thorax, several patches of capillary extravasation were observed under the costal pleura. Both lungs were crowded with

App. No. 6.

On Disinfectants, by Dr. Baxter.

yellowish nodules of infective pneumonia, varying in size from a pea to a pigeon's egg. They were all firm and somewhat elastic; when subpleural, they were surrounded by a zone of congestion, but the pleura over them retained its normal smoothness. Trachea and bronchi full of frothy secretion. The mucous membrane lining the nasal cavities was much reddened; no nodules were detected in it on a cursory inspection.

Results from Series C.

The result of the three experiments in this series is incontestable. The presence of 2 per cent. of carbolic acid, or of ·4 per cent. of sulphur dioxide sufficed to destroy the infective power of the virus employed, and the presence of ·5 per cent. of carbolic acid did not impair its virulence in the least.

V. Experiments with Septic Microzymes.

Relation of disinfectant power to certain other properties.

In the introductory part of the present report it was stated that much of what had been hitherto done by way of determining the relative efficacy of disinfectants was radically vitiated by the very loose meaning attached to the term. Numerous experiments have been made in order to ascertain the power of various agents to prevent or arrest catalytic, zymotic, and septic processes; and the results of such experiments have long been taken as a measure of comparative disinfectant power. Further, some authors fail even to distinguish between the destruction of the noxious products of putrefactive decomposition and that of the specific contagia. This last element of perplexity may, however, be summarily dismissed; the problem is obviously and wholly chemical; the nature of the liquid or volatile products whose hurtful influence is dreaded in any particular case, necessarily defining the nature of the agent required to decompose or to combine with them. But the former series of results is deserving of closer attention. For although their employment as a means of estimating the comparative power of various disinfectants depends on the implied assumption of some fundamental relationship between the mode in which such processes are propagated and that in which communicable diseases are spread, and although no such assumption can at present be regarded as sufficiently established to serve as a basis for deductive inference, yet it is clear that had no similarity been noticed between the effect of disinfectants on the processes above enumerated, and their utility in arresting the spread of contagious disease, the practical good sense of inquirers would soon have led them to retrace their steps and abandon a method of investigation yielding results in obvious contradiction to those of everyday experience. A method based—perhaps unconsciously—upon a hypothesis in which many of those who employed the method did not believe, must have owed its continued popularity to coincidences observed to hold good between the two sets of phenomena. This seems the most likely explanation of what wears, at first sight, the aspect of a paradox; viz., that the very persons who repudiate all belief in the parasitic theory of contagion, nevertheless continue to put faith in disinfectants whose claim to credit logically depends on the truth of some such theory.

These considerations appeared to furnish a motive for discussing the question by the light of the facts ascertained in the foregoing series of experiments. It seemed worth while to ascertain, if possible, whether any relation could be demonstrated between the strictly disinfectant properties of the substances under investigation, and their power to influence catalytic, zymotic and putrefactive processes. Should the existence of some such relation turn out not to be wholly imaginary, it will tend, *pro tanto*, to support a particular view of contagion; though the acceptance of the connection need not of course entail the acceptance of the pathological theory.

Its relation to the power of checking or arresting catalytic change.

The first of the three processes, whose relation to disinfectants has been studied, is the peculiar catalytic change determined in certain compounds by a nitrogenous ferment, and seemingly independent of the presence of living organisms. The analogy between such catalytic processes and the phenomena of contagion and infection is most clearly present to the mind of those pathologists who attribute an infective power to all the albuminoid constituents of the diseased organism, a power depending entirely upon their molecular condition, and independent of the "vital" endowments of the corpuscular elements of the blood and tissues. The obscurity which shrouds the intimate nature of any such process is expressed rather than explained by the term "catalysis." That there exists a certain show of likeness between the two sets of phenomena it would be unfair to deny; and even those most firmly attached to the hypothesis never claim for it the authority of a demonstrated truth.

The following catalytic processes have been studied in relation to carbolic acid: the action of emulsin upon amygdalin, that of myrosin on the myronate of potash contained in black mustard-seed, that of emulsin upon salicin, that of saliva and diastase on starch, that of pepsin on albumen and fibrin.* It may briefly be said that the acid, unless present in very large proportions, is incapable of exercising any material influence on any of these processes except the last; and even the last is not very susceptible to its influence; for Zapolsky found it necessary to add 5 drops of the pure acid to 10 cubic centimètres of artificial gastric juice in order to arrest its solvent action on ·5 gramme of fibrin.

The relation of the remaining three disinfectants on our list to the above processes has not, so far as I know, been studied; nor is this of any moment; for the results obtained with carbolic acid are sufficient to prove that the phenomena of catalysis cannot furnish any analogies to disinfection, strictly so called.

Its relation to the power of checking or arresting fermentation.

We have next to consider the influence of disinfectants upon fermentations causally associated with the presence of organisms of the *Torula* kind. Of these, alcoholic fermentation is the familiar type. Many writers habitually place fermentations and putrefactions in the same group, and deal with them as essentially similar processes. From a chemical point of view, this may be justifiable. But it is not to the chemical results of the process, it is to the organic forms associated with the production of those results, that our attention has to be directed. One writer on disinfectants (Dr. Dougall, *loc. cit.*) has been at great pains to distinguish between what he calls the "antifermentative" and the "antiputrefactive" power of various agents, and to express their relation to each other numerically, the sum of the two constituting what he terms "total antiseptic power." The chief differences between the two sets of phenomena may be summarised as follows:—

1. Fermentations are associated with the presence of torulaceous organisms, putrefactions with that of bacteroid forms.

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* Those desirous of fuller details are referred to the following authorities: *Zapolsky* (Hoppe-Seyler's *Med. Chem. Untersuchungen*, 1871); *Lemaire* (l'Acide Phénique); *Plugge* (Die Carbolsäure, *Pflüger's Archiv*, vol. X. 1872); *Crookes* (Report on Disinfectants, Cattle Plague Commission, 1866); *W. Buchholtz* (Die Einwirkung der Phenylsäure auf einige Gährungsprozesse. Inauguraldiss. Dorpat, 1866).

App. No. 6.

On Disinfectants, by Dr. Baxter.

2. The former occur by preference in acid, the latter in neutral or alkaline media.

3. The germs needed to excite the former are abundantly present in air; those required for the latter are sparingly distributed through air, but abundant in water.

4. The chemical changes wrought by the former are much more rapid than those wrought by the latter.

5. The organisms connected with fermentation are more easily destroyed, or robbed of their reproductive power, than those associated with putrefaction.

It must, of course, be understood that this attempt to separate between the two groups of phenomena is entirely relative to the matter now in hand; it would be highly presumptuous to offer it as the solution of a many-sided problem which must one day be settled upon wider grounds.

The action of disinfectants on the organisms connected with fermentation need not detain us long. There is much evidence to show that fermentation is far more easily arrested than putrefaction; and that torulaceous germs are more susceptible to the action of heat (Roberts, Studies on Biogenesis, *Phil. Trans.*, 1874), and to that of chlorine and of potassic permanganate, than the germs of the *Schizomycetes*. Jüdell* has shown that the exposure of yeast to an atmosphere containing ·25 per cent. (by volume) of SO_2 for a variable number of hours destroys its zymotic properties. Manassein found $\frac{1}{16}$ per cent. of carbolic acid sufficient to deprive the spores of *Penicillium* of their germinating power. Experiments made by myself point in the same direction. It may fairly be concluded that the influence of disinfectants on such fungoid spores affords no measure of their action on contagia, since the former are very much more susceptible to adverse influences than the latter.

Its relation to the power of checking or arresting putrefaction.

The strictly antiseptic energy of disinfectants is undoubtedly that which has been most thoroughly investigated, and most frequently taken as a measure of their power to destroy contagion. A vast mass of experimental material on this subject has been accumulated by Angus Smith, Calvert, Crookes, Parkes, O'Nial, Dougall, and many others in this country, not to speak of countless researches made in France and Germany. The popularity of this method has been shown to depend, partly on a vague sense of resemblance between the spread of putrefaction and that of contagion; partly on a belief that specific contagia may be created *de novo* in putrefying matter; partly on coincidences empirically observed between the operation of disinfectants in the two sets of cases; partly on the difficulty of obtaining direct evidence of their value. Without committing ourselves to any opinion on the vexed question of the parasitic theory of contagion, it seems desirable to find out whether any quantitative relation between the antiseptic and the disinfectant power of our four agents can be shown to exist. It is needful to premise that the word "antiseptic" is here taken to mean "fatal to the growth and multiplication of septic microzymes." The nature of the connexion between microzymes and the chemical phenomena which coincide with their evolution is provisionally set aside. Whether putrefactive decomposition may occur as a result of purely chemical agencies, and without the intervention of bacteroid organisms, is a question foreign to the matter in hand. Hoppe-Seyler† has proved to his own satisfaction that it may. But the analogies of the contagia are with septic microzymes, not with processes of oxidation or deoxidation. Septic microzymes, like the contagia, multiply indefinitely when introduced, in all but infinitesimal proportions, into suitable media; so far the analogy is shared by the torulaceous ferment-organisms; on the other hand, septic microzymes, like contagia, thrive in alkaline or neutral media; and organisms morphologically identical with them have been shown to exist in many infective liquids.

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* *Hoppe-Seyler's Untersuchungen*, 1868.

† *Med. Chem. Untersuchungen*, 1871. Uber Fäulnissprozesse und Desinfektion.

True nature of the analogy between putrefaction and contagion.

Before describing the experiments, it is necessary to clear up a preliminary misconception which has been a source of endless confusion in the past. The antiseptic power of a given agent has usually been tested by adding it, in some known proportion, to a substance capable of serving as a nidus for the evolution of septic microzymes, and noting whether it succeeded or failed in preventing their appearance. Now there can be no question that small quantities, say of carbolic acid, are able to prevent the growth of microzymes in media otherwise favourable to them; that minute proportions of potassic permanganate or chlorine added to such media may so act upon the materials which are the pabulum for microzymes as to deprive them of their nutritive power. Thus, for example, $\frac{1}{3}$ per cent. of carbolic acid suffices to prevent the putrefaction of bread pulp, $\frac{1}{5}$ per cent. that of flesh-broth, and of milk.* Such proportions, as we have seen already, are destitute of disinfectant power; and all idea of a quantitative correlation would have to be abandoned, were this the only, or the correct method of investigation. The real question is this: what proportion of a given disinfectant, added to a liquid containing microzymes or their germs, will deprive these of their power to multiply when introduced into a medium hitherto barren, but endowed with all the conditions of fertility. The following was the method adopted in seeking an answer to this question.

Method employed for tracing a quantitative relation between antiseptic and disinfectant power.

A known proportion of the agent under investigation was added to a liquid teeming with septic microzymes. A test-solution, previously sterilised by heat, was then inoculated with a minute drop of the disinfected† liquid. If it continued barren, the successful destruction of the septic germs was proved; in the event of their incomplete destruction, the test-liquid was found crowded with their progeny. The septic microzymes were invariably cultivated in Cohn's solution,‡ modified by the omission of the calcium phosphate; this solution, as is well known, remains permanently limpid and barren after being boiled, if protected against accidental contamination; on the other hand, the introduction of the smallest quantity of septic microzymes, or of their germs, renders it turbid in 48 hours. The first experiment of the series will be fully described, as an illustration of the method of procedure; of the subsequent ones, the results only will be given.

I. *Action of Potassic Permanganate on Septic Microzymes.*

Experiments with potassic permanganate.

1. Six éprouvettes were charged with 1 c.c. each of Cohn's solution, swarming with microzymes. Each éprouvette then received 1 c.c. of one of the following six solutions of permanganate in distilled water: 1, 8 per cent.; 2, 6 per cent.; 3, 4 per cent.; 4, 2 per cent.; 5, 1 per cent; 6, ·5 per cent. The liquids in the six éprouvettes were

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* Plugge.

† In describing the following experiments, the terms "disinfected," "infective," &c. are, of course, used metaphorically.

‡ Its composition is as follows:

Ammonium tartrate, 2 grm.
Magnesium sulphate } of each 1 grm.
Potassic phosphate }
Calcium phosphate, ·1 grm.
Distilled water, 200 c.c.

The calcium phosphate does not dissolve properly in the liquid, and interferes with its limpidity; it may be omitted without detriment.

thus made to contain 4, 3, 2, 1, ·5, and ·25 per cent. respectively of the disinfectant. They were set aside for some hours under a bell-jar. Eight fresh éprouvettes were in the meantime thoroughly roasted in the flame of a Bunsen burner. Into each of these 3 c.c. of boiling Cohn were introduced, and they were set aside to cool under cover. When cool the first six were inoculated with one drop each of the six disinfected solutions; the seventh was left without interference; the eighth was inoculated with a drop of the original liquid which was crowded with microzymes. Each inoculation was performed with a distinct pipette which had previously been roasted and cooled. The eight éprouvettes were then plugged with cotton wool, and set aside under a bell-jar. At the end of a week the first seven were found absolutely limpid and barren. The eighth was milky, and coated with a scum of bacteria.

2. The disinfected solutions contained the following proportions of permanganate: 1, ·5, ·25, ·125, ·0625, ·03125 per cent. The test-liquids inoculated with all of them remained barren, while that inoculated with the original solution became quickly turbid.

3. Proportion per cent. of the permanganate: ·125, ·0625, ·03125, ·015625, ·0079, ·0039. The last solution only, that containing ·0039 per cent. was found to have retained its infective power.

II. *Action of Chlorine on Septic Microzymes.*

Experiments with chlorine.

1. Proportions by weight of chlorine in disinfected solutions: ·0428, ·0214, ·00428, ·00214 per cent. Test-liquids inoculated all proved barren.

2. Proportions of chlorine per cent.: ·008, ·004, ·0016, ·0008, ·0004. All the test-liquids remained barren except the last, inoculated with a solution which contained ·0004 per cent. of the gas.

III.—*Action of Sulphur Dioxide on Septic Microzymes.*

Experiments with sulphur dioxide.

1. Proportion of SO_2 per cent. in disinfected solutions: ·528, ·0528, ·0264, ·00528, ·00264. Of the test-liquids inoculated from these solutions, one only, that inoculated with the solution containing ·528 per cent. of SO_2, remained barren.

2. Proportion of SO_2 per cent. ·495, ·248, ·123. All the test-liquids remained barren.

3. Proportion of SO_2 per cent. ·552, ·776, ·194. All the test-liquids proved barren.

IV.—*Action of Carbolic Acid on Septic Microzymes.*

Experiments with carbolic acid.

1. Proportion of carbolic acid per cent. in disinfected solutions; 4, 3, 2, 1, ·5, ·25. Test-liquids all remained barren except that inoculated with solution containing ·25 per cent. of the acid.

2. Proportion of carbolic acid per cent. 2, 1, ·5, ·25, ·125. Test-liquids inoculated with the first two proved barren, those with the last three, fertile.

3. Proportion of carbolic acid per cent. 1, ·5, ·25, ·125, ·0625. Test-liquids inoculated with first two proved barren; with last three, fertile.

Summary of results.

The somewhat unexpected results of these four series of experiments may be thus briefly summarised: the microzymes which swarm in Cohn's solution are completely deprived of reproductive power by potassic permanganate, when present in the proportion of ·007 per cent. or more; by chlorine, when present in the proportion of ·0008 per cent. or more; by sulphur dioxide, when present in the proportion of ·123 per cent. or more; by carbolic acid, when present in the proportion of 1 per cent. or more. The time during which the microzymes were exposed to the action of the disinfectant did not appear to matter; intermixture having been thoroughly accomplished, the work was done.

Apparent discrepancy between antiseptic and disinfectant power.

The striking *primâ facie* discrepancy between these figures and those obtained in the series of experiments performed with vaccine lymph, would have led to the abandonment of the inquiry, had not the results of Davaine's experiments on the virus of charbon (p. 22.) awakened the suspicion that the discrepancy was more apparent than real. It is noteworthy that the difference was greatest in the case of chlorine and potassic permanganate; least in the case of carbolic acid; and that the figures obtained with the virus of glanders and of infective inflammation, were less widely removed from those representing the antiseptic power of the four agents, than those obtained in the case of vaccine.

Attempt to elucidate the nature of this discrepancy.

There are two alternative explanations possible: it may be that the particles of contagium differ so essentially from one another and from the germs of septic microzymes in their susceptibility to adverse conditions, that no common prospect, whether of destruction or survival, can be held out to all of them alike; on the other hand, it is possible that the particles are all equally liable to perish when brought into contact with the same disinfectants; and that the discrepancy observed is entirely due to differences in the medium in which the particles may happen to float. The probability of the latter explanation is enhanced by the reflexion that septic microzymes, which are admittedly of one kind, vary widely in the degree of their resistance to destructive agencies, according to their physical condition and environment.*

In order to obtain some evidence on which to found a judgment between these two conflicting views, the following experiments were carried out. It was obviously impossible to vary the nature of the medium in which the particles of vaccine virus are suspended—a medium strongly alkaline, and loaded with coagulable principles,—owing chiefly to the small quantity of material available for experiment. So that, in the first place, an attempt was made to alter the constitution of the medium containing septic microzymes, and by bringing it more nearly into relation with the albuminoid matrix of vaccine lymph, to ascertain whether changes made in this direction were attended by any corresponding change in the susceptibility of the septic germs to the action of chlorine and permanganate.

Experiments with septic microzymes.

I. Two solutions containing active microzymes in abundance, were prepared as follows: (*a*) by mixing 2 c.c. of turbid Cohn with 18 c.c. of water; (*b*) by mixing 2 c.c. of turbid Cohn with 18 c.c. of ovalbumin. The former was neutral, the latter feebly alkaline. Each solution was divided into three parts, and potassic permanganate was introduced in the following proportions:

1*a* and 1*b* received ·0125 per cent.
2*a* „ 2*b* „ ·00625 „
3*a* „ 3*b* „ ·003125 „

The solutions were all shaken and put under a bell-jar. Eight éprouvettes, charged with sterilised test-liquid, having been prepared, six were inoculated from the above six solutions; the seventh received a drop of (*a*); the eighth, a drop of (*b*). After a week had elapsed, it was found that the test-liquids inoculated from the three disinfected solutions which contained no albumen, were barren; while the other five were turbid and swarmed with microzymes.

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* No particular evidence in support of this assertion need be given, for nearly all the facts adduced during the recent controversy on spontaneous generation are illustrative of its truth.

Another experiment of a similar kind showed that the presence of ·025 per cent. of permanganate failed to destroy the reproductive power of septic microzymes suspended in an albuminous medium.

II. An experiment of the same kind was performed with chlorine. It was found that proportions of ·016, ·008, and ·004 per cent. of the gas proved fatal to septic microzymes in a watery medium, and harmless to the same microzymes in an albuminous one.

Another experiment was carried out with larger proportions of the disinfectant: it was found that ·1954 per cent. succeeded in destroying the septic germs both in the albuminous and in the aqueous media, while ·065, ·033, and ·016 per cent. succeeded in aqueous and failed in albuminous solutions. After the chlorine had been incorporated with the solutions they were all tested with iodide of potassium and starch; free chlorine was found in *all* the aqueous solutions, but only in the first of the albuminous ones, that in which its antiseptic power was alone manifested.

The results of the above experiments are strongly in favour of the view that the difference between septic germs and the particles of vaccine virus, as regards their susceptibility to chlorine and permanganate, depends chiefly, if not entirely, on the difference of the media in the two cases. Similar trials made with sulphur dioxide and carbolic acid yielded results of another order, as will be seen from the following account of them.

III. Septic microzymes suspended in aqueous and albuminous media were exposed to the action of carbolic acid in proportions of ·5, 1, and 2 per cent. The acid was found to sterilise both the aqueous and the albuminous solutions in proportions of 1 and 2 per cent., and to fail in both alike when present in the proportion of only ·5 per cent.

IV. Similar experiments with sulphur dioxide showed that when present in proportions of 1·5, ·77, and ·194 per cent., the gas destroyed the reproductive capacity of septic microzymes both in albuminous and aqueous media.

It thus appears that the action of potassic permanganate and chlorine on septic germs is interfered with by the presence of albumen in the medium in which the germs float; and that the protective power of albumen is less marked, if it exist at all, in the case of sulphur dioxide and carbolic acid.

Experiments with virus of infective inflammation.

An endeavour was now made to corroborate the inference from these experiments by following another line of inquiry. Although, as has been stated before, it was not found possible to modify the medium in which the particles of vaccine are suspended, the same difficulty was not presented by the virus of infective inflammation. Accordingly a sufficiency of viscid matter from the peritoneum of an infected guinea-pig having been procured, it was divided into two equal parts; one was directly exposed to the action of potassic permanganate, the other was freed from all soluble admixture by repeated washing and decantation.* The latter liquid ultimately consisted of nearly pure saline solution in which flocculi of exudation were suspended; under the microscope these flocculi were seen to consist of corpuscular elements, studded with minute refracting particles (*Micrococci?*). This latter liquid was mixed with permanganate in the same proportions as the former one; the result of the series of inoculations performed with the two kinds of virus is given in the following table.

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* This method is the same as that adopted in the case of glanders virus, and described on p. 24.

App. No. 6.

On Disinfectants, by Dr. Baxter.

Series.	No. of Animal.	Weight in Grammes.	Date of Inoculation.	Material Inoculated.	Dose.	Proportion of Disinfectant in the Material Inoculated.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
X.	27	462	October 30	Washed virus (flakes of exudation suspended in saline solution) diluted with equal volume of water.	3½ ♏	0	5 days	Infective peritonitis; viscid, colourless exudation; surface of liver smeared with yellowish flaky lymph. No pleurisy or pericarditis. Changes at site of inoculation inconsiderable.
	28	532	Do.	Same washed virus with equal volume of permanganate solution.	3½ ♏	·05 per cent. of permanganate.	- - -	No symptoms. Used for another experiment on January 14.
	29	510	Do.	Ditto - - - -	3½ ♏	·025 per cent. of permanganate.	- - -	Ditto.
	30	470	November 4	Same virus, but not washed; highly viscid and coagulable. Diluted with equal volume of saline solution.	3½ ♏	0	4 days	Local changes as in 27. Peritonitis with viscid exudation and abundant flaky lymph. Double pleurisy and pericarditis.
	31	610	Do.	Same virus, not washed, mixed with equal volume of permanganate solution.	3½ ♏	·05 per cent. of permanganate.	6 days	Peritonitis, left pleurisy, and pericarditis. Nature of exudation same as in 27 and 30.
	32	508	Do.	Ditto - - - -	3½ ♏	·025 per cent. of permanganate.	3 days	Peritonitis with scanty reddish exudation. No pericarditis or pleurisy.

The result of this very demonstrative experiment, when taken in conjunction with that of Davaine's experiments on charbon virus suspended in a watery liquid (p. 22), places the protective influence of the medium above all question, at least as regards potassic permanganate. The following two series of experiments were designed to ascertain whether the disinfectant activity of chlorine was capable of being interfered with by alkalinity of the virulent medium, or by the presence in it of albuminous matter.

Series.	No. of Animal.	Weight in Grammes.	Date of Inoculation.	Material Inoculated.	Dose.	Proportion of Disinfectant in the Material Inoculated.	Interval of Time between Inoculation and Death.	Post-mortem Appearances, and Remarks.
XI.	33	300	February 11	Virus 5 parts; 10 per cent. solution of sodic carbonate 1 part. Strongly alkaline. The virus was the same as that employed in series III.	5 ♏	0	16 hours	Same appearances as in No. 7.
	34	560	Do.	Virus 4 parts; saline solution 1 part; chlorine water 1 part. Distinctly acid; traces of pure chlorine can just be detected by iodide of potassium and starch.	5 ♏	·0544 per cent. chlorine.	- - -	No symptoms. In perfect health on March 16.
	35	888	Do.	Virus 4 parts; 10 per cent. solution of sodic carbonate, 1 part; chlorine water, 1 part. Strongly alkaline; free chlorine present in abundance as shewn by potassic iodide and starch.	5 ♏	·0544 per cent. chlorine.	- - -	Ditto.
XII.	36	645	February 16	Virus, 1 part; saline solution, 3 parts. Neutral. Same virus as in series XI.	5 ♏	0	36 hours	Same appearances as in No. 33.
	37	428	Do.	Virus, 1 part; saline solution, 2 parts; chlorine water, 1 part. Contains free chlorine in abundance.	5 ♏	·0793 per cent. chlorine.	- - -	No symptoms. Quite well on March 16.
	38	390	Do.	Virus, 1 part; ovalbumin, 2 parts; chlorine water, 1 part. No free chlorine to be detected.	5 ♏	·0793 per cent. chlorine.	24 hours	Same appearances as in No. 33.

On Disinfectants, by Dr. Baxter. Summary of results.

The above results tend to the conclusion that a high degree of alkalinity of the virulent medium does not impair the disinfectant power of chlorine, while the presence of a certain proportion of albumen nullifies its activity.

To sum up: tho evidence of the foregoing experiments, such as it is, points in one direction, and lends support to the view that such quantitative differences as seem at first sight to exist between the disinfectant action of chlorine and potassic permanganate on the various contagia on the one hand, and on the germinal matter of septic microzymes on the other—and those differences are very marked—are chiefly, if not entirely, due to differences in the naturo of the medium in which the particles, whether of septic or of contagious matter, are suspended. Carbolic acid and sulphur dioxide seem to be less at the mercy of the medium in which they are required to operate; accordingly the quantitative difference between the action of carbolic acid on the contagia, and its action on septic microzymes, is trifling when compared with that exhibited by chlorine and the permanganate.

Hence it follows that the destructive action of a substance on the reproductive power of septic microzymes does really appear to afford some clue to its strictly disinfectant properties; but that, in order to make antiseptic a measure of disinfectant energy, it is essential to follow the method of inquiry recommended above, to understand "antiseptic" as synonymous with "fatal to the reproductive power of microzymes," and to eliminate chemical phenomena of putrefaction as altogether foreign to the subject. Further, it must never be forgotten that the nature of the medium in which the particles, whether septic or contagious, are embedded or suspended, exerts a modifying influence of the most striking kind on the susceptibility of the particles themselves to disinfectant agents.

Principal inferences from the above research embodied in the form of propositions.

It may be well, in conclusion, to embody the principal inferences which seem to flow from the results of the foregoing investigation in a series of propositions. The basis of induction furnished by it is, of course, a relatively narrow one; but, though narrow, it appears to be more secure than that which has hitherto been built upon.*

1. Evidence has been adduced to show that carbolic acid, sulphur dioxide, potassic permanganate, and chlorine, are all of them endowed with true disinfectant properties, though in very various degrees.

2. It is essential to bear in mind that antiseptic is not synonymous with disinfectant power, though, as regards the four agents enumerated above, the one is, in a certain limited sense, commensurate with the other.

3. The effectual disinfectant operation of chlorine and potassic permanganato appears to depend far more on the nature of tho medium through which the particles of infective matter are distributed, than on the specific character of the particles themselves.

4. When either of these agents is used to disinfect a virulent liquid containing much organic matter, or any compounds capable of uniting with chlorine, or of decomposing the permanganate, there is no security for the effectual fulfilment of disinfection short of the presence of free chlorine or undecomposed permanganate in the liquid after all chemical action has had timo to subside.

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* These propositions are simply meant to help the reader in gaining a succinct view of the more practical bearings of the foregoing research; the evidence on which some of them rest is obviously too limited in *quantity*, though of the right *kind*, to allow of their laying any claim to finality.

5. A virulent liquid cannot be regarded as certainly and completely disinfected by sulphur dioxide unless it has been rendered permanently and strongly acid. The greater solubility of this agent renders it preferable, *cæteris paribus*, to chlorine and carbolic acid, for the disinfection of liquid media.

6. No virulent liquid can be considered disinfected by carbolic acid unless it contain at least 2 per cent. by weight of the pure acid.

7. When disinfectants are mixed with a liquid, it is important to be sure that they are thoroughly incorporated with it; that no solid matters capable of shielding contagium from immediate contact with its destroyer be overlooked.

8. Aerial disinfection, as commonly practised in the sick-room, is either useless or positively objectionable, owing to the false sense of security it is calculated to produce. To make the air of a room smell strongly of carbolic acid by scattering carbolic powder about the floor, or of chlorine, by placing a tray of chloride of lime in a corner, is, so far as the destruction of specific contagia is concerned, an utterly futile proceeding.

9. When aerial disinfection is resorted to, the probability that the virulent particles are shielded by an envelope of dried albuminous matter, should always be held before the mind. Chlorine and sulphur dioxide are, both of them, suitable agents for the purpose; the latter seems decidedly to be the more effectual of the two. The use of carbolic vapour should be abandoned, owing to the relative feebleness and uncertainty of its action. Whether chlorine or sulphur dioxide be chosen, it is desirable that the space to be disinfected should be kept saturated with the gas for a certain time, not less than an hour; and this in the absence of such gaseous compounds as might combine with or decompose the disinfectant, and so far impair its energy.

10. When the thorough disinfection of a mass of solid or liquid matter, through which a contagium is disseminated, is impracticable,* we should guard against giving a false security by the inadequate employment of artificial means. It is probable that all contagia disappear sooner or later under the influence of air and moisture, and that the absence of these influences may act as a preservative. When, therefore, we cannot advantageously or effectually supersede the natural process of decay, we must be sure that we do not hamper it by the injudicious use of antiseptics.

11. Dry heat, when it can be applied, is probably the most efficient of all disinfectants. But, in the first place, we must be sure that the desired temperature is actually reached by every particle of matter included in the heated space;† secondly, length of exposure and degree of heat should be regarded as mutually compensatory factors, within certain limits.

The above statements are not so discouraging as they may appear at the first glance to our reliance upon artificial disinfection. If we believe that all contagia are generated, like those of small-pox and scarlet fever, in the infected organism, and there only, the out-look is a hopeful one. We might even anticipate an approach to the *perfect* fulfilment of the work of disinfection, by subjecting all matters, immediately after their removal from the affected person, and before any dilution or admixture, to the full influence of one or other among the destructive agencies at our command. On the other hand, if the contagium of any disease is capable of being generated *de novo* outside the body (pythogenic origin of enteric fever, typhus created by overcrowding) such contagium can hardly be eradicated by any method of artificial disinfection. For cases of the latter kind, the opening words of the memorandum previously referred to, furnish the only solution. "It is to cleanliness, ventilation, "and drainage, and the use of perfectly pure drinking-water, that "populations ought mainly to look for safety against nuisance and "infection. Artificial disinfectants cannot properly supply the place "of these essentials; for, except in a small and peculiar class of cases, "they are of temporary and imperfect usefulness."

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* As an example, we may take the accumulation of manure and litter from a number of animals suffering from cattle-plague.

† This point has been investigated, and its importance established, by Dr. Ransome.

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